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Title:

Australian Telecommunications CRC

Annual Report 2004/2005

Established and supported under the
Australian Government's Cooperative Research Centres Programme

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1 Objectives

The Australian Telecommunications Cooperative Research Centre (ATcrc) was established to provide a cooperative environment for developing and commercialising the technologies that will drive a new generation of telecommunications. Through its ability to assemble valuable resources and diverse skills, ATcrc offers a unique set of research and development capabilities in networking and mobile telecommunications. With significant investment in its education and training programs, ATcrc will transfer expertise in technologies such as digital radio, packet networking, digital signal processing and electronic design into Australian industry. This transfer will occur through the Centre's uniquely qualified post-graduate students, as well as industry-specific training courses.

ATcrc is committed to:

- Creating commercial opportunities in international markets
- Creating commercial vehicles that will attract venture funding
- Creating processes for quality implementation of new designs
- Transferring skills and technology into Australian industry to address the global market

ATcrc is pleased to retain the support of its core partners:

- Curtin University of Technology
- The University of Western Australia
- Monash University
- RMIT University
- Victoria University
- CSIRO
- Ericsson Australia Pty Ltd
- Vodafone Network Pty Ltd

2 Executive Summary

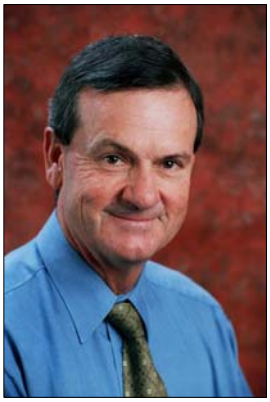
In the sixth year of ATcrc's operation, research, education and commercialisation activities continued to contribute significantly to the Australian ICT climate. After the unsuccessful Telcore Broadband CRC rebid, ATcrc has shifted its focus to investigating other revenue sources for its research programs and producing commercial outcomes for its intellectual property.

ATcrc had a stand at CeBIT Australia, Sydney, 24-26 May 2005, that attracted a good number of visitors. As well as general information about the CRC, there were displays of three ATcrc items and one WATRI project. CeBIT is a highly visible, annual ICT exhibition and ATcrc's stand was located in the *future parc* section dedicated to R&D in the industry.

ATcrc's marketing activities continued with an increased role in the organisation of regional ICT industry academic conferences. ATcrc is significantly involved in the organisation of *Tencon'05*, the *2005 Asia-Pacific Conference on Communications* and the *Vehicular Technology Conference (VTC), Spring 2006*. VTC has been running for over 50 years and 2006 will be the first time it has been held in the southern hemisphere.

Other achievements ATcrc has accomplished in the last year are highlighted in the Chair and CEO Reports.

3 Chair's Report



The focus of the sixth year of the Australian Telecommunications CRC (ATcrc) moved from supporting a new CRC bid to positioning the CRC to complete its commitments and facilitate an orderly wind-up of activities in the seventh year.

Research Collaboration

The Telcore Broadband CRC proposal was submitted in July 2004. It proposed a much expanded research and commercialisation partnership continuing many of the themes of ATcrc and with only some of the existing partners. ATcrc was notified in November 2004 that the bid for funding had not been successful.

It was subsequently decided that the CRC joint venture should be dissolved at the end of current funding and when all the commitments to the Commonwealth had been met. ATcrc has been assisting the contributing research groups to seek other sources of funding once the CRC ends. It is unlikely that much direct collaboration between groups will continue beyond the CRC. In this context, ATcrc welcomes the funding of ACoRN (ARC Communications Research Network), which has taken up education collaboration in areas of interest to the CRC.

Budget Restructuring

The contract variation for the ATcrc's Commonwealth Agreement was finally signed by all partners and the CRC Programme in August 2004. This provided a new budget context that recognised current industry conditions in which future commercial revenue would not reach levels initially planned. It enabled the CRC's activities to be trimmed to fit existing resources.

The Board has ensured that ATcrc should be able to meet all its liabilities in its final two years. While this has taken cash out of research and education activities, it has been partially offset by personnel changes in which senior staff have been replaced by more junior ones. ATcrc enters its final year with a healthy cash position, sufficient to meet all outstanding commitments.

Review Follow-Up

The fifth-year review, held in May 2004, made seven recommendations, of which five concerned collaboration or commercialisation. The Board has carefully tracked actions on each of these recommendations, with a view to identifying new commercial opportunities for the CRC's research. Some actions, particularly with regard to closer cooperation with CSIRO, are still ongoing.

Xelor Software, Inc. (formerly Cortec Systems)
ATcrc's commercial spinoff company, Cortec Systems, was "flipped up" to a US entity in November 2004 and renamed Xelor Software, Inc. Its Xelorate family of products provides quality-of-service management for voice on Internet systems. With the leadership of a US management team, Xelor has continued to meet its technical development milestones while re-examining its "go to market" strategy. The third tranche of funding from the Australian investors was provided in March 2005 and, at the end of the year, Xelor was seeking further funding to support its operations.

ATcrc, together with the other Australian founders, appointed Pete Bonee, of Sylantro Systems Corporation, to the Xelor Board in March 2005.

Commercial Prospects
During the course of the year, ATcrc undertook several internal reviews to ensure that all commercial prospects were being pursued. In the Wireless Program, a review in August 2004 concluded that there were no immediate commercial prospects from the Radio Access Technologies project. The other major project, Adaptive Antennas, in this Program is the subject of active commercial promotion.

Following the fifth-year review, the project on Frameworks for Development of Next Generation Internet Applications in the Applications Program was further reviewed in August 2004. A target application in support of emergency services communication has been identified but it is unlikely that commercial exploitation will be possible during the remaining life of the CRC.

The Networking Program projects have been refined around two topics with commercial potential.

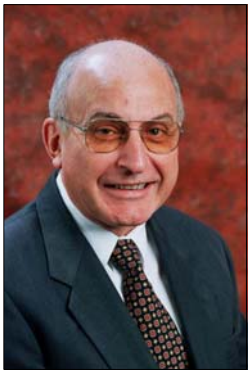
It was pleasing to receive the first payments during the year from an R&D agreement with Samsung Advanced Institute of Technology (Korea) although total commercial revenue fell short of target. This was due to Australian Photonics going into voluntary administration, before making its final payment to ATcrc, and to rescheduling of the Samsung project.

The Board also agreed to trim ATcrc's Intellectual Property portfolio to return patents with little commercial prospect to the originating organisations. This included several patents from the predecessor CRC. ATcrc had engaged QPSX to undertake the review on which these decisions were based.

Prescient Networks Pty Ltd
Prescient Networks was created as the commercialisation agent for the CRC in 1999/2000. As part of the preparation for its continued existence beyond 2006, the shareholding in Prescient was restructured to leave the ownership in the hands of Curtin University, the CRC's Centre Agent. Prescient can continue beyond the life of the CRC and manage the equity in spin-offs and valuable intellectual property for the benefit of the ATcrc's core partners.

Peter Harley
Chairman

4 CEO's Report



After the failure of the CRC rebid, ATcrc declared two major themes. The first was "continuity"; finding ways to continue the research programs with other funding. The second was "commercialisation", gaining maximum commercial pull-through from research and education and supporting technology transfer. These themes will continue to drive the CRC in its final year.

Research Programs

With increased emphasis on commercialisation and technology transfer, ATcrc continued to strengthen its ties to international standards bodies (see below) in its Applications Research and Wireless Research Programs. This provided valuable connections for the researchers.

In the Applications Research Program, the emphasis remained on Internet Protocol, version 6 (IPv6), particularly in a mobile environment. A large group of documents from the research is now under consideration by the Internet Engineering Task Force (IETF), the Internet's standards-setting body. The relationship with Samsung led to further performance comparisons of competing methods for "fast handovers" of Internet devices between wireless networks.

Also in the Applications Research Program, the Frameworks for Development project, the subject of a recommendation from the fifth-year review, was redirected to support for emergency-services communications.

Networking research was continued around "OptiFlow", a framework for performance management of IP networks. This led to a collaboration with Telstra Research Laboratories over the most effective methods for traffic engineering in Internets, a study which is ongoing. It also led to a new proposal for an enterprise overflow router for small or medium enterprises.

In the Wireless Research Program, there were continued fundamental advances in methods for increasing the communications capacity of wireless links. A collaboration with Tait Electronics has provided the foundation for a testbed for multi-input, multi-output (MIMO) wireless systems. This may lead to a new commercial opportunity. Further development of the CDMA scanner has been stopped but the instrument has been used for several measurement campaigns.

The Communications Electronics Research Program has brought its theme of timing impairments in electronic systems to a conclusion. The design techniques will be useful for future high-speed electronic designs. The other theme of control of fibre amplifiers is continuing.

Standards Involvement

International communications standards are a key driver of change in telecommunications. ATcrc has continued to support collaboration with relevant bodies.

In the IETF, ATcrc's Applications Program is a key player in the development of standards for Mobile IPv6, especially in the standards for maintaining a session when a mobile internet device moves from one wireless connection to another. Some 30 documents called "IETF drafts" with ATcrc authors are under consideration by the IETF.

The IEEE standards organisation is the major standards body for electronic devices and wireless LANs. The ATcrc group at Victoria University has been contributing unique MIMO methods to a new standard for wireless LANs, IEEE 802.11n. This has increased the international profile of the group.

The propagation studies performed using the CDMA scanner have been contributed, via CSIRO, to the relevant ITU-R study group and have refined the reference standard.

Commercialisation

The R&D contract with Samsung Advanced Institute of Technology (Korea) continued throughout the year. Its final deliveries have slipped into 2005/2006. The contract has resulted in continuing and detailed collaboration with Samsung. A new patent application is expected as part of the output of this collaboration.

Several prospects for commercialising the output from the Adaptive Antennas project were investigated during the year. The aim has been to find a partner who can use the project results and the project team to

develop new products for wireless LANs. It is hoped that a new spinoff, in which ATcrc retains some equity, can be created.

The R&D agreement with Australian Photonics Pty Ltd was terminated after the company went into voluntary administration and it was clear that the final payment would not be received.

Education and Training
For the PhD program, the final top-up scholarships to be offered were agreed in March 2005. For the current students, support will be continued beyond the life of the CRC up to 3.5 years of candidature. It is expected that 11 scholarship holders will complete after June 2006.

The last vacation student program was run during the 2004/2005 summer vacation. The students finished with presentations of their work in Melbourne and Perth in February 2005. The vacation students have made valuable contributions to the CRC's projects over the past four summers.

There has been increasing interest in short training courses during the year. The "Introduction to IPv6" course was run successfully a number of times for commercial clients. A number of other topics have generated commercial interest but it has been difficult to find sufficient resources for full-scale course development.

Marketing
The main marketing event for the year was the ATcrc stand at CeBIT Australia, Sydney, May 2005. This was an opportunity to exhibit three CRC items and one project from WATRI. A significant number of new contacts were made.

ATcrc continued to publish its newsletter, *Wave*. Issue 9 was distributed in April 2005 to over 500 local and international contacts.

As part of the Australian Innovation Festival, ATcrc ran an "education showcase" in Melbourne. There were exhibits of a number of student projects and a presentation by a senior researcher. The event was poorly attended and it is unlikely that the CRC will participate directly in the Innovation Festival again.

After reviving the *Australian Telecommunications, Networks and Applications Conference (ATNAC)* in 2003, ATcrc assisted the Smart Internet Technology CRC to organise *ATNAC 2004* in Sydney, December 2004. ATcrc is also assisting with the organisation of IEEE *Tencon 2005* (IEEE Region 10 Conference), of which *ATNAC* will be a part, to be held in Melbourne in November 2005.

Other international conferences coming to Australia with support from ATcrc include the *Asia-Pacific Conference on Communications* (APCC), Perth, October 2005, and IEEE *VTC-Spring*, Melbourne, May 2006, the major conference for wireless technology and devices.

Collaboration
ATcrc and the SITCRC are proposing to collaborate in the area of mobile internet. A joint project involving the development of an advanced mobile application was being defined at the end of the financial year.

A collaboration with Telstra Research Laboratories over traffic engineering for Internets is proceeding. From ATcrc's viewpoint, it is hoped that this may lead to an R&D contract with Telstra.

Financial Performance
Commercial revenue for the year fell short of target due to two factors. The first was that the final payment from Australian Photonics Pty Ltd was not received when the company went into voluntary administration and was subsequently reorganised.

The second factor was rescheduling of the R&D Agreement with Samsung Advanced Institute of Technology. The third and fourth deliveries under the agreement have slipped into 2005/2006 and the consequent payments have been delayed.

Despite the setbacks to commercial revenue, ATcrc had a healthy cash balance at the end of 2004/2005. Year-end cash was greater than target mainly due to lower than expected spending on salaries, as senior staff left and were replaced by more junior ones.

Personnel Changes
ATcrc lost its two Associate Directors during the year when Professor Hans-Jürgen Zepernick left WATRI and Professor Richard J. Harris left RMIT University. Both took positions overseas. Professor Gregory Egan of Monash University was appointed an Associate Director in April 2005. He had become Research Director

of the Applications Research Program in August 2004, after Dr Khee Pang of Monash had resigned from the role. Dr John Murphy, the Program Leader of the Networking Program, left RMIT at the end of his contract in December 2004.

In light of these personnel changes, Dr Manora Caldera at WATRI became the interim Program Leader for the Wireless Research Program, replacing Professor Zepernick; and the Networking Research Program was placed under the management of the Applications Research Program. These changes, including a new *Schedule 5: Specified Personnel,* were communicated to the CRC Programme in March 2005.

Mr Stuart Cole, Business Development Manager, and Ms Sarah Craze, Education and Marketing Manager, have transferred their employment to Capital Technic Consulting and are contracted back to the ATcrc. This arrangement provides continuity of employment beyond the life of the current CRC.

Leith H. Campbell
Chief Executive Officer

5 Governance, Structure and Management

5.1 The Board of Management

The Board of Management has overall responsibility for ATcrc performance. Board members are drawn from the broad telecommunications industry and ATcrc's research partners.

At 30 June 2005, the voting members of the Board of Management were:

Mr Peter Harley, Chair;
Professor Antonio Cantoni, Independent Board member;
Mr Greg Crew, Independent Board member;
Professor Akhtar Kalam, representing the Victorian universities;
Dr Jhong Sam Lee, External Board member;
Dr Laurie Mackechnie, Independent Board member;
Professor Doug McEachern, representing the WA universities.

Dr Leith Campbell, CEO, is an ex-officio, non-voting member of the Board.

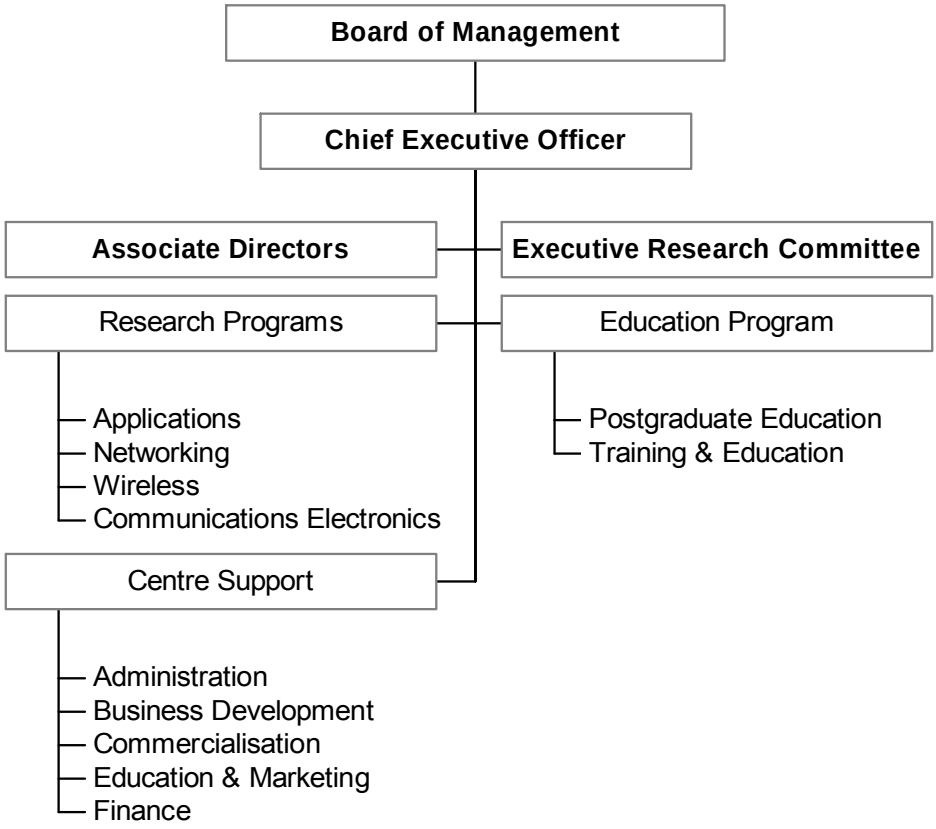
Four Board of Management meetings were held during 2004/2005. The following table shows the number of meetings each Board member was eligible to attend and the number actually attended.

Name	Eligible to Attend	Attended
Mr Peter Harley	4	4
Professor Antonio Cantoni	4	2
Mr Greg Crew	4	3
Professor Akhtar Kalam	4	3
Dr Jhong Sam Lee	4	2
Dr Laurie Mackechnie	4	4
Professor Douglas McEachern	4	4
Dr Leith H Campbell	4	4

Profiles of ATcrc's Board Members are available from the ATcrc website at http://www.telecommunications.crc.org.au

From left: Professor Richard Harris, Dr Laurie Mackechnie, Professor Doug McEachern, Mr Peter Harley, Dr Leith Campbell, Mr Gregory Crew, Professor Tony Cantoni and Professor Akhtar Kalam. Photographed at ATcrc Headquarters, Perth WA, May 2004. Absent: Dr Jhong Sam Lee.

5.2 ATcrc Governance Structure



For membership of the Executive Research Committee, see section 10, Specified Personnel. The Executive Research Committee met five times during 2004/2005, two weeks before each Board meeting.

5.3 ATcrc Membership

ATcrc is pleased to retain the ongoing support of its core partners:

- Curtin University of Technology
- Monash University
- RMIT University
- University of Western Australia
- Victoria University
- CSIRO
- Ericsson Australia Pty Ltd
- Vodafone Network Pty Ltd

A contract variation, with effect from 1 July 2003, signed by the Commonwealth on 26 August 2004, confirmed the current core partnership of the CRC.

ATcrc's supporting partners are:

- CEOS Pty Ltd
- QPSX Pty Ltd
- State Government of Victoria, Department of Innovation, Industry and Regional Development
- Tait Electronics (New Zealand)
- Western Australian Office of Science and Innovation

In accordance with the original agreement signed in 1999, the support of Sun Microsystems came to an end in June 2004. ATcrc gratefully acknowledges Sun's contributions to the computing infrastructure of the CRC.

6 Commercialisation/Technology Transfer/Utilisation

6.1 Commercialisation/Utilisation Strategies & Activities

Xelor Software Inc, USA (previously Cortec Systems Pty Ltd)
Cortec Systems was successfully spun-out from ATcrc in late 2003, with the research team responsible for this project also transferring to Cortec Systems as part of its inaugural staff. During early 2004, $6M of Series-A venture capital funding was raised from three venture capital companies, to fund Cortec's proposed product development strategy and business plan implementation.

In late 2004, Cortec Systems Pty Ltd was migrated into a new US-based entity, Xelor Software Inc., a registered Delaware company, with headquarters established in Salem, New Hampshire, USA, so as to be better able to service target early-adopter companies and to access US venture funding.

Xelor Software is currently in negotiations to undertake its Series-B equity capital raising in the USA.

Wavebreaker AB, Nanoradio AB (Sweden) & ATcrc Joint Venture Proposal
In December 2003, ATcrc signed a conditional Letter of Intent with Acreo AB (Sweden) to develop and commercialise separate but complementary technologies and intellectual property. The work was in the areas of high-throughput wireless LANs and MIMO antenna technologies.

In June 2004, with Acreo AB financial backing, nineteen of the Acreo AB research staff agreed to spin out into a new company, Wavebreaker AB (Sweden). An in-principle agreement, subject to funding, was made to form an Australian-based Wavebreaker subsidiary company to commercialise ATcrc's Adaptive Antennas project.

Wavebreaker AB and ATcrc conducted significant international capital-raising efforts during late 2004 and early 2005, but ultimately could not raise sufficient funds on acceptable terms to proceed with the proposal. The agreement was terminated in 2005.

In early 2005, another Swedish start-up company, Nanoradio AB, which had been watching Wavebreaker AB's efforts and which was also interested in ATcrc's Adaptive Antennas project, attempted to step into the commercialisation partner role with ATcrc. Unfortunately, it was unable to complete the required equity raising. This commercialisation activity was also terminated in early 2005.

During the year, ATcrc's Adaptive Antennas project was also presented in detail to a number of Australian venture capital funds and ICT SMEs, including Allen & Buckeridge Asset Management Ltd, Starfish Ventures and Cohda Wireless Pty Ltd.

Separate commercial negotiations for ATcrc's Adaptive Antennas project to partner with Clarinox Technologies Pty Ltd and Phoenix Asia Corporation Ltd (Hong Kong) in the development of in-train video, entertainment and communications systems were progressed. However, the commercial partners withdrew after it became clear that ATcrc could not guarantee access to many researchers beyond its lifetime. ATcrc's research programs are due to wind down from late 2005.

MAP Venture Partners (MVP) & ATcrc Joint Venture Proposal
In mid-2005, ATcrc commenced discussions with MVP regarding the commercialisation of ATcrc's Adaptive Antennas project, with a new spin-out company expected to emerge from these discussions in late 2005.

Networking Program Commercialisation (Australia)
ATcrc's Networking Program developed two potential commercial product concepts during the year:

- OptiFlow
- Enterprise Overflow Router

ATcrc's OptiFlow project is for an IP-based network traffic management, optimisation and analysis tool that has generated interest from Telstra Research Laboratories (TRL). TRL and ATcrc are conducting a series of simulated network management tests. OptiFlow was also presented to a number of Australian venture capital funds and KAZ Technology Services to determine market interest in funding the development of a commercial-grade demonstrator, but has yet to find a funded commercialisation partner.

The Enterprise Overflow Router project is currently the subject of an intellectual property review to assess areas of patentability. Commercial discussions with selected partners are on hold until this intellectual property protection process is completed. A prospective lead commercial partner has been identified.

R&D Contract with the Private Sector (Korea)
ATcrc undertook paid contract R&D work for Samsung Advanced Institute of Technology during the year, with deliverables including a new patent application and technical reports.

SME Collaboration – the Australian i-Mode Forum
ATcrc was a founding sponsor of the Australian i-Mode Forum, managed by Digital Investor Pty Ltd. The Forum is an unincorporated association of SMEs interested in developing 2.5G network compatible i-Mode services and applications that has strong links to the European i-Mode Forum.

6.2 Telcore Broadband CRC (ATcrc Round 9 CRC Rebid) Proposal

ATcrc, with the other eight ICT-based Round 9 CRC bids, was unsuccessful in securing an award of a CRC Grant for Telcore Pty Ltd, the bid vehicle for the proposed A$100M+ Telcore Broadband CRC bid. Subsequently, a number of ATcrc's leading university-based ICT professors have permanently left Australia, and a number of others have been on extended sabbatical leave. A number of the proposed SME industry partners in the Telcore Broadband CRC have also migrated some commercial operations offshore. ATcrc views this as a regrettable outcome for the long term sustainability of the Australian ICT R&D sector.

6.3 Other Commercialisation

ATcrc's associated company, Prescient Networks Pty Ltd, holds ATcrc's formal intellectual property for commercial purposes.

ATcrc's patent on statistical multiplexing, licensed to QPSX Communications Pty Ltd (QPSX) in 2002/2003, was formally transferred to QPSX in early 2005. This was to protect ATcrc and its Centre Agent from any third-party intellectual property infringement or defence actions that may arise in response to QPSX's plans for an assertion program of these intellectual property rights. This may lead to further licence income for ATcrc.

Total commercial revenue of $131,667 was received during the year. This was below the revised target of $180,000 for commercial revenue for a number of reasons, including the collapse of Australian Photonics Pty Ltd, which owed ATcrc $35,000.

6.4 IP Management

ATcrc's Business Development Manager works closely with all Research project leaders whose work shows commercial promise and intervenes early to ensure that patent opportunities are identified and assessed. Applications are prepared where deemed appropriate.

ATcrc utilises the services of two firms of Patent Attorneys to assist with this process and maintains a detailed Patent Register of granted patents and filed patent applications. ATcrc has a detailed IP Policy for intellectual property management.

One new patent application was lodged during the year:

- Channel Estimation for OFDM Systems

ATcrc also manages intellectual property generated by a predecessor CRC, the CRC for Broadband Telecommunications and Networking (CRC-BTN). During the year, much of this intellectual property was

returned to Curtin University to manage. By resolution of the Board in August 2004, the following patents were returned to Curtin University:

- Dual Sensing Opto-Electronic Receiver
- Precise Digital Frequency Detection
- Steered Frequency Phase Lock Loop
- Switching Protocol Providing Controlled Access to Available Asynchronous Network Service (CCT)

6.5 End-User Involvement

Organisation	Description	Contact
CSIRO (core partner)	Commercialisation of W-CDMA Scanner instrument or measurement service.	Dr Leith Campbell Mr Stuart Cole
Ericsson Australia (core partner)	Consultancy.	Dr Leith Campbell
QPSX Communications Pty Ltd	Transfer of patent on statistical multiplexing, as part of a proposed intellectual property assertion program, with royalty stream due to be received by ATcrc upon a successful action.	Dr Leith Campbell Mr Stuart Cole
QPSX Communications Pty Ltd Foundation Management (IIF) Pty Ltd Starfish Ventures Pty Ltd TVP No. 3 Fund Nominees Pty Ltd	Xelor Software Inc. (USA) Cortec Systems – Australian joint venture, flipped up into the USA. Spin-off company to commercialise and export technology related to Voice over IP.	Dr Leith Campbell Prof Tony Cantoni
Acreo AB, Sweden Wavebreaker AB, Sweden Various international venture capital funds	Letter of Intent to develop spin-off company to commercialise and export technology related to high throughput W-LAN and MIMO.	Mr Scott Leyonhjelm Prof Mike Faulkner Mr Stuart Cole
Telstra Research Laboratories Kaz Technology Services Pty Ltd Various Australian venture capital funds	Collaboration and testing of the OptiFlow IP-based network traffic management, optimisation and analysis tool.	Dr Leith Campbell Prof Richard Harris Mr Stuart Cole
Samsung Advanced Institute of Technology	R&D Contract to develop new intellectual property.	Dr Ahmet Sekercioglu Mr Stuart Cole
Clarinox Technologies Pty Ltd Phoenix Asia Limited	Collaboration to develop in-train communications, video and entertainment service – terminated.	Mr Stuart Cole
Australian Photonics CRC	Collaboration on optical technology and network management – terminated.	Prof Richard Harris
Capital Technic Group Pty Ltd	Unwinding of TelCore CRC bid proposal. Outsourcing of ATcrc's Business Development and Marketing & Education roles, to assist with skill retention by ATcrc.	Dr Leith Campbell
Digital Investor Pty Ltd	Sponsorship of the Australian i-Mode Forum, and its inaugural event.	Dr Leith Campbell Mr Stuart Cole

Organisation	Description	Contact
Alcatel Australia Alchemedia Solutions Capital Technic Group Pty Ltd Chat) Zoo Pty Ltd Cliksafe Australia Electronic Science Corporation FindMap Pty Ltd Fluffy Spider Technologies Pty Ltd Halo Pictures Pty Ltd RedRock Communications Pty Ltd Telstra Corporation Ltd Viva La Mobile Pty Ltd WAN TV (Plus other commercial partners, not named due to non-disclosure constraints)	A$100M TelCore CRC rebid application commercial R&D syndicate, with collaboration around 4 Research programs: 1. Building the Future of Wireless Devices & Infrastructure 2. Building the Future of Broadband Devices & Infrastructure 3. Middleware for Next Evolution Networks 4. Advanced Services & Applications Bid terminated due to failure in Round 9 CRC application.	Dr Leith Campbell Mr Stuart Cole

6.6 Progress Against Contractual Targets/Milestones

The table below documents ATcrc's progress in achieving the Schedule 6 Performance Evaluation criteria in the ATcrc Commonwealth Agreement during the 2004/05 year.

Criteria	Outcome
Extent of advice and advisory services provided to industrial Parties, as well as firms and institutions which have not contributed to the Centre.	Advice provided to: • Ericsson Australia • Samsung Electronics (Korea) • Clarinox Technologies Pty Ltd • Digital Investor Pty Ltd • Tait Electronics (NZ)
The number of times research results have been transferred to a company to be assessed for development	Research results were assessed by: • Telstra Corporation Ltd • Ericsson • KAZ Technology Services Pty Ltd • QPSX Communications Pty Ltd • Cohda Wireless Pty Ltd • Exinda Networks Pty Ltd • MAP Venture Partners Pty Ltd • Allen & Buckeridge Asset Management Ltd • SciVentures Pty Ltd • Starfish Ventures Pty Ltd • Jolimont Ventures Pty Ltd • Clarinox Technologies Pty Ltd • Capital Technic Group Pty Ltd • Doughty Hansen (UK) • Wavebreaker AB (Sweden) • Nanoradio AB (Sweden)

Criteria	Outcome
The number of project outcomes that have been commercialised.	One – via Xelor Software, Inc. (USA)
The value of the product, process or service to the company marketing it, in terms of sales, market share, and contribution to turnover.	Nil. Xelor Software, Inc. is a start-up company. This data has not been made available by other industry partners.
The value of the product, process, or service in increasing exports or import substitution.	Nil. Xelor Software Inc is now a foreign company, based in the USA. This data has not been made available by other industry partners.
The contribution of the product, process or service to the development and diffusion of new standards or methods in the relevant user industry.	This data has not been made available by industry partners. Collaborative forums supported by ATcrc to promote knowledge sharing between Australian ICT SMEs included sponsoring the establishment of the Australian i-Mode Forum by Digital Investor Pty Ltd.
The establishment of spin-off companies by the Centre.	Nil in the current year. One over the life of ATcrc.
The estimated or actual financial returns to Australia stemming from the R&D.	This data has not been made available by industry partners.
The contribution of the activity, findings or advice to the development and diffusion of new standards, regulations or methods in the relevant user industry or other users.	ATcrc contributed to the following international standards bodies: • Internet Engineering Task Force • IEEE 802.11n • ITU-R Study Group 3
The extent to which the skills and resources of the Centre are drawn on by industry or other users (eg., consultation, contract research, use of facilities)	R&D contract with Samsung Advanced Institute of Technology (Korea). Two small consultancies for Ericsson Australia.

7 Research

7.1 Applications Research Program

Overview

There is now a wide variety of different wireless devices that can connect to the Internet and an unlimited array of applications for their use. For these devices to work effectively, there needs to be constant, standardised and flexible access at all times. The Applications Program is dedicated to two different but connected solutions to these issues. The *Next Generation Internet* project team works towards the development and adoption of key communication protocols for these devices. The *Frameworks for the Development of NGI Applications* team has developed an application that allows the automation of dynamic distribution of information between different mobile devices.

Technology Context

The research focus for this Program is part of the worldwide research effort to create IPv6-based next generation telecommunication networks. The aim is to enhance the capabilities of IPv6-based mobile networks and support real-time communications.

7.1.1 Next Generation Internet

Overview

The ICT industry is developing new technologies for flexible Internet access through a variety of mobile devices (PDAs, portable computers and cellular phones) over wireless links. This access flexibility requires creation and standardisation of a new set of communication protocols to be added to the software architecture of the Internet. ATcrc's Next Generation Internet project, by working together with its industry partners, is developing new key protocols and actively working towards their standardisation and adoption.

Technology Context

The research focus is part of the worldwide research effort to create IPv6-based next generation telecommunication networks. The aim is to advance Mobile IPv6 handover optimisation standards and IPv6-based video client/server tools. This will enhance the capabilities of IPv6-based mobile/cellular networks and support real-time communications.

Progress against Contractual Milestones/Targets

Description of Milestone	Milestone date as per Commonwealth Agreement	Achievement Date (or proposed achievement date if milestone not met)
Programming staff appointed	Not provided	September 2001
Target proposal and platform identified	Not provided	October 2001
Investigation of layer two triggering for standard MIPv6 handovers	Not provided	February 2004
Software specification complete	Not provided	December 2001
Hierarchical handover agent implementation code	Not provided	Media Release published August 2002 stating code is available for download.
Fast Handover technique implementation code	Not provided	Due to the rapid changes in the standardisation process this activity has been cancelled (RFC 4068 standardisation has been completed in July 2005). Team efforts have been focused on non-predictive fast handover methods instead.
Fast Handover integration with layer two triggers	Not provided	March 2003

Description of Milestone	Milestone date as per Commonwealth Agreement	Achievement Date (or proposed achievement date if milestone not met)
System demonstration	Not provided	August 2005
System conformance confirmed	Not provided	December 2001
Interoperability testing	Not provided	December 2001 (Interop Budapest)
Performance data for system components	Not provided	December 2005

Research Planning & Activities

A core component of the project team's work throughout the year centred around the completion of the Samsung MIPv6-based Seamless Handover project milestones. The Edge Handover simulation models were completed and tested. A final report and analysis of performance, including patent documentation, is in preparation.

The team increased its involvement with the Internet Engineering Task Force (IETF). The development of Standards in this area was originally focused around the Detecting Network Attachment Working Group. However, the Samsung project findings and completed work concerning Optimistic Duplicate Address Detection strategies for the mobile Internet have attracted IETF interest.

The "Introduction to IPv6 Protocols" workshop continued to attract interest from industry and the research community.

Research Collaboration

The Panasonic Project has been structured as support for a PhD student. Work has been progressing well with a number of research papers prepared.

The team has contributed to the standardisation process of Ericsson's HMIPv6 protocol. The team has implemented the protocol and, as a result of this, Ericsson has discontinued the work on its own implementation.

A collaborative project with the Networking Program concerning traffic engineering using traditional IP routing protocols has been discontinued due to the departure of key Networking Program staff.

Initiatives and Breakthroughs

The project team's efforts within the IETF have focused on the performance of Mobile IPv6 handovers. Mobile IPv6 is a system that allows a device to change its point of attachment to a network, and thus its IP address, while presenting a consistent address both to applications and to other devices it is communicating with.

The process of handover involves several steps and can take many seconds, imposing a heavy toll on applications such as IP telephony, where consistent performance is required. The team has investigated those handover steps and worked to reduce them or their impact. It has produced many contributions to the IETF, and has tested these and others through implementation.

The result is a set of techniques that can significantly reduce handover latency in mobile IPv6, independent of the link technology it is deployed over.

Intellectual Property

- IPv6 course material
- Hierarchical Mobile IPv6 protocol code implementation
- IPv6 fast router advertisement code implementation
- Optimistic duplicate address detection code implementation
- Router advertisement link identification for Mobile IPv6 movement detection code implementation
- Edge handovers for Mobile IPv6 code implementation

- Tunnel buffering for Mobile IPv6 code implementation
- Tentative source link-layer address options for IPv6 neighbour discovery code implementation
- Deterministic fast router advertisement configuration code implementation
- Nonce response matching for router reachability code implementation
- DNAv6 detecting network attachment in IPv6 networks code implementation
- IPv6 simulation models

7.1.2 Frameworks for the Development of Next Generation Internet Applications

Overview

Next-generation mobile applications' users must experience performance comparable to current desktop and LAN-based application scenarios. Targeting different devices and maintaining multiple codebases is difficult and costly. It also slows the development of applications that can effectively utilise existing and future communications infrastructure. Application and Internet service providers are facing increasing costs as developers look to thin-client solutions to avoid the complexities of client-side development on multiple devices. Unfortunately, this leaves client resources unused, servers overloaded and end users with unresponsive user interfaces.

This project is dedicated to the development of a prototype for the automation of dynamic distribution of information and the execution of applications over heterogenous devices. The prototype is known as MobJeX.

Technology Context

Potential areas for exploiting the emerging infrastructure cover enterprise and business oriented solutions through to rich multimedia-based video games and online/virtual communities. There is much scope for community-oriented applications, such as the co-ordination of volunteer workers or support for emergency services. Likely industry partners include SME software development houses and application service providers.

Progress against Contractual Milestones/Targets

Description of Milestone	Milestone date as per Commonwealth Agreement	Achievement Date (or proposed achievement date if milestone not met)
Development of MobJeX prototype	n/a (new project)	May 2005
Development of mobile collaborative CASE	n/a (new project)	March 2007
Publications detailing MobJeX and Mobile Collaboration.	n/a (new project)	6 refereed publications in high profile international and Local conferences. One more publication possible before the end of 2005.
Attracting undergraduate and postgraduate students to project	n/a (new project)	During the lifetime of the project, there have been 5 honours students, 1 PhD student and 4 vacation students.

Research Planning & Activities

A Research Fellow was recruited to assist with the development of a prototype of the MobJeX system. The development of the prototype was completed in May 2005. A demonstration was prepared for the ATcrc stand at CeBIT Australia 2005. It showed the dynamic participation of mobile nodes.

Work on the development of mobile collaborative computer aided software engineering is progressing. Simulations have been performed on an improved version of the SOCT algorithm for use in mobile applications. This work has been published at an IEEE International Conference. Work has commenced on dynamic participation and group joining/leaving.

Research Collaboration

Collaborations have been pursued and commercialisation opportunities are under discussion. The possibility of patenting the core algorithms of the MobJeX system is underway, in collaboration with Freehills patent attorneys.

Initiatives and Breakthroughs

The project achieved a major milestone with the development of the MobJeX prototype and the associated publications.

Future Directions

Ongoing work involves the possibility of patenting the core MobJeX algorithms and collaboration with Emergency Services. As part of this process, a detailed technical report has been drafted. It describes how MobJeX technology can assist in the co-ordination of emergency services within a specific group, e.g. Ambulance or Police, and between different groups.

7.2 Networking Research Program

7.2.1 Dynamic Management of Networks

Overview

The Networking Program focuses on the development of techniques for optimally routing Internet and wireless traffic; the management of network failures and overloads; and development of methods for acceptable delays for all classes of traffic.

A fundamental requirement is the efficient delivery of these services and the need to guarantee that Quality of Service (QoS) standards are met. To ensure QoS, the correct implementation of network traffic management principles is necessary. This involves accurate configuration of routers and switches, capacity and topology management and the implementation of call admission control and traffic shaping schemes.

Technology Context

Internet Service Providers and traditional telecommunications carriers require solutions that can transport their traffic efficiently with minimal delay or congestion. Inefficient traffic routing leads to over-provisioning of the network's capacity, potentially causing severe localised congestion. To enable accurate modelling and management, the need for detailed traffic information is underpinning decisions on Internet and wireless network traffic routing.

Progress against Contractual Milestones/Targets

Description of Milestone	Milestone date as per Commonwealth Agreement	Achievement Date (or proposed achievement date if milestone not met)
2.1.1 Optimal Routing in IP Networks		
Incorporation of failure mode calculations into the LP solution	December 2004	December 2004
Prototype Routing Tool development, demonstrations and enhancements	September 2005	June 2005
Application of LP techniques to the management IP networks, models and methodology	March 2005	March 2005
2.1.2 Traffic Measurement and Analysis §		
Report on time-series characterisation of traffic required for modelling and simulation studies to assess suitability of techniques for the Prototype Routing Tool.	December 2004	December 2004

Description of Milestone	Milestone date as per Commonwealth Agreement	Achievement Date (or proposed achievement date if milestone not met)
2.1.3 Optimal Routing Strategies in Mobile Networks §		
Publication of papers and reports on new routing protocol	March 2005	March 2005
GPPP standard proposal.	September 2004	September 2004

§ These milestones were only partly achieved since key personnel left ATcrc.

Research Planning & Activities

Optimal Routing in IP Networks
OptiFlow, the traffic optimisation tool developed last year to quickly remove sudden congestion in networks, has undergone testing and simulations. Interest in the tool has been expressed by Telstra Research Laboratories and the work has resulted in a number of publications.

Methods for the estimation of network traffic have been studied, implemented and compared. These include the Interior Point Method, Expectation and Maximisation and Weight Changes. The results have been submitted for publication.

Enterprise Overflow Router
A new project initiated during the year, the Enterprise Overflow Router, is an Internet traffic usage maximisation appliance that improves the efficiency of multiple internet connections in a cost-efficient manner. It is currently in the initial stages of commercialisation.

Optimal Routing Strategies in Mobile Networks
A handover procedure for heterogeneous wireless technologies has been investigated and a simulation model is being developed. A model for multicasting over wireless networks has also been developed. The project will conclude with the testing of algorithms presented for micro-mobility protocols and observation of performance of handoff latency and packet losses.

Research Collaboration

A joint study comparing OptiFlow optimal routing with MPLS traffic engineering is in progress with Telstra Research Laboratories.

Professor Richard Harris, the former Networking Program Research Executive and now with Massey University in New Zealand, continues in a supervisory role with the three PhD students attached to the project.

There have been informal research collaborations with Sanjay Bose (NTU Singapore) and Bill Lloyd-Smith (RMIT) concerning mathematical models to describe overflow routing in IP networks.

Initiatives and Breakthroughs

The direction of the project has changed significantly. The major milestones laid out in the Commonwealth Agreement have been achieved. The project's focus is now on commercialisation activities for the OptiFlow tool and the Overflow Enterprise Router.

7.3 Wireless Research Program

Overview

The rollout of third generation wireless networks in Australia has given greater impetus to research in this area. The Wireless Program undertakes research into increasing reliability, efficiency and capacity of third- and fourth-generation systems. It combines theoretical and practical measurement approaches in its three projects.

Technology Context

The Wireless Program combines theory, measurement and practical implementations to provide advances in performance and capacity of next-generation wireless systems. The emphasis is on third- and fourth-generation networks.

7.3.1 W-CDMA Scanner

Overview

The W-CDMA Scanner and the software developed in this project allow the careful planning of the locations and attributes of base stations for mobile communications, specifically for the Australian landscape and conditions. The W-CDMA Scanner has these uses:

- It can provide measurement services (e.g. for operators to check cell sites and actual coverage);
- Detailed channel information can be used to develop receiver structures and processing algorithms under more realistic conditions (compared to traditional simulations).

Progress against Contractual Milestones/Targets

All milestones from the Commonwealth Agreement were completed in June 2004. New milestones were developed to allow for the reduction in resources for the project.

Description of all milestones	New Milestone Date	Achievement Date (or proposed achievement date if milestone not met)
Journal paper	April 2005	November 2005: Awaiting results from ITU-R meeting
Proposed revision to Recommendation ITU-R P.1546-1. (Improved definition of effective transmitting/base antenna height.)	July 2005	October 2005. Presented at the Australian Radio Study Group 3 meeting, April 2005. To be presented to the ITU-R in October 2005.

Since establishing the new milestones, a second journal paper has been commenced.

Research Planning & Activities

The official time allocated by the project's partner, CSIRO, was reduced to nil. Support has been forthcoming in an unofficial capacity.

The core activities of the year concerned the publication of findings from the project. The project has contributed to the validity of the new ITU-R Recommendation P.1546 in a mobile, rural environment, as well as identifying areas of further improvement for the Recommendation.

Two journal papers are in progress and have been delayed due to new discoveries and findings. The suburban measurement campaign was postponed to accommodate holiday and conference travel.

Initiatives and Breakthroughs

Modelling and validation with existing measurement data

The revised version of Recommendation P.1546-1 was evaluated and showed severe problems with the new terrain clearance angle correction curves. For the same line of sight scenario, the predictions using the new method were on average 16dB different compared to the previous version and not at all compatible with the Okumura-Hata model. This is highly unusual and will be incorporated into the Recommendation being presented in October 2005.

Research Collaboration

Collaborations with Telstra Research Laboratories and Blekinge Institute of Technology, Sweden have been established.

7.3.2 Adaptive Antennas

Overview

Multiple antenna technologies increase data rates and extend the range in third and fourth Generation Mobile Cellular, Wireless Local Area Networks (WLAN) and Broadband Wireless Access (BWA) networks.

One advanced type of multiple antenna technology is called Multiple Input/Multiple Output (MIMO), having multiple antennas at both the base-station and the user terminal. MIMO is a technique that can be used to exploit indoor or dense urban environments where many versions of the same signal arrive at the receiver with different time delays, via different routes. Conventional single antenna radio systems, such as those used in a mobile handset, suffer performance degradation in these conditions, whereas MIMO systems can exploit the multipath characteristics of these environments to their advantage. In simple terms, if one antenna receives a poor signal, then it is likely that the other antenna is receiving a better version of the signal. The benefits of multiple antenna techniques are:

- Increased Data Throughput
- Increased Link Robustness resulting in extended coverage
- Increased system capacity for a given spectrum allocation

Technology Context

WLAN is integrated into most laptop computers. Unfortunately, the maximum usable data rate of 30 Mbps falls far short of the standard 100 Mbps Ethernet connection used in offices today. Next generation wireless LAN systems with higher speed will also enable broadband distribution of high definition TV and Voice over IP-based applications. The Adaptive Antennas project is actively engaged in developing MIMO based proposals for the next generation WLAN standard (IEEE 802.11n), targeting fixed or low mobility access in non-line-of-sight urban environments. The initial goals are to demonstrate, through simulation, the performance benefits of MIMO techniques and, through the development of a real-time prototype, that the MIMO technology gives a tangible benefit in a real office environment.

Progress against Contractual Milestones/Targets

All milestones from the Commonwealth Agreement were partially achieved by the due dates to June 2004. The following milestones cover unfinished activities.

Description of Milestone	New Milestone Date	Achievement Date (or proposed achievement date if milestone not met)
Dynamic Channel Measurement	June 2005 (student thesis submission)	December 2005
Real Time Demonstrator	September 2005	May 2006
MIMO Simulator	December 2005	May 2006
Array Calibration	December 2004	December 2004
ASIC developments (Active Duplexer)	February 2006 (student thesis submission)	May 2006
Commercialisation	May 2006	

Research Planning & Activities

The project team's core activities over the year have centred around the completion of a proposal for the Next Generation WLAN (IEEE 802.11n) standardisation process, supported by simulation results, and commercialisation activities, supported by the real time MIMO demonstrator.

Real Time MIMO Demonstrator

The goal of the Real Time Demonstrator has been modified to match the resources allocated to the project until commercialisation opportunities can be realised to expand the scope of the Demonstrator. Currently all pieces are being integrated together and, by September 2005, it is expected that a demonstration of a

pseudo real-time MIMO wireless link will be ready. Achievements to date have included the development of a USB2.0 interface to enable a 100 Mbps data link from a computer to the MIMO prototype, a Linux-based application and user interface to generate live video content, and the necessary FPGA-based functions for implementing the MIMO prototype.

MIMO Simulator

The partial proposal for the IEEE 802.11n standard was presented at the September and November meetings in 2004. The team subsequently joined the "TGn Sync" consortium in December 2004 with a view to participate in defining the MIMO-based proposal – the basis of the eventual standard.

Work commenced to merge the two MIMO wireless Link simulators into one, called WAVESIM. This will enable the capture of intellectual property value from all members of the team. A considerable amount of the project's resources were used throughout the year for this activity. In February, the merge was completed and Version 1.0 of the WAVESIM MIMO wireless link simulator was released. Two further releases occurred in April and June respectively, Version 1.1 and 1.2. Future work will focus on including the latest developments from the 802.11n standardisation effort.

Research Collaboration

The collaboration with Tait Electronics Ltd (Christchurch, NZ) continued with visits and presentations from both groups occurring. The project continues to use the Tait hardware platform for developing the real time MIMO demonstration.

Commercialisation Activities

The project pursued MIMO technology-based commercialisation opportunities with a start-up fabless IC company from Sweden, called Wavebreaker. However, in November 2004, after 18 months of effort and without any realistic prospects on the horizon, this initiative was not continued. Shortly afterwards, two agreements were signed with wireless start-up companies, although these have been put on hold due to funding and timing constraints.

The project is still actively pursing other initiatives to commercialise the technology and know-how that has been developed by the project.

Initiatives and Breakthroughs

The project has surpassed its objectives laid out in the Commonwealth Agreement.

A sustained effort has been made over the last two years to commercialise the project's technology and know-how. To date, the commercialisation effort has been very beneficial in increasing the projects outcomes through setting and communicating clear objectives. As a result this has:

- focused the technical developments toward a tangible commercial application, as demonstrated by the participation in the next generation WLAN standard;
- focused the researchers to work as a team toward achieving objectives within a given time frame;
- brought about an awareness of the importance of the intellectual property process.

The project has also been acutely aware of balancing the academic and commercial objectives. This can be best demonstrated by:

- using the commercialisation objectives of the project staff to give the postgraduate students a framework from which they are exposed and given insight into the latest industry relevant problems. The result should be reflected in a more rounded, innovative and industry aware postgraduate. Six of the 11 students that have graduated are now working in Industry in Australia or overseas.
- Protecting Australia's intellectual property interests by having a well-defined intellectual property process within the project, resulting in two patent applications and other ideas that are yet to be disclosed, whilst continuing to publish, on average, five journals and 18 conference papers per year.

7.3.3 Radio Access Technologies

Overview

The demands future wireless communication systems will make on data rate, link quality and spectral efficiency cannot be met by conventional systems. Significantly higher data transmission rates and reduced costs per transmitted bit will be essential. In a real world situation, the critical influence of impairments, such as imperfect synchronisation, on the performance of a technique is often neglected.

This project aims at improving radio link quality and making efficient use of limited bandwidth resources. Major focus is given to broadband wireless indoor channels. Algorithms, techniques and transceiver structures suitable for implementation in software or a chip-set are being developed. Performance of these schemes is highly dependent on specific wireless environments. Therefore, a software channel simulator for respective radio channel regimes is in development.

Technology Context

The evolution of digital mobile communications, along with the increase of integrated circuit complexity, has resulted in frequent use of link adaptation techniques and efficient radio access technologies. However, implementation complexity increases with the introduction of these advanced algorithms, so an approach for reducing overall system complexity is needed.

For example, frequency domain approaches and multi-rate sub-band schemes are gaining considerable attention as a means of reducing implementation complexity of equalisers. A major challenge in transceiver design is to understand and find a reasonable trade-off between radio link quality, complexity, and implementation requirements.

Progress against Contractual Milestones/Targets

All milestones from the Commonwealth Agreement partially achieved by the due dates to June 2004. The following milestones cover unfinished activities.

Description of Milestone	New Milestone Date	Achievement Date (or proposed achievement date if milestone not met)
Adaptive modulation on ARQ schemes	Carried forward	Intending to continue research with postgraduate students
Investigation of real time implementation issues	Carried forward	Intending to continue research with postgraduate students
Joint equalisation and decoding algorithms	Carried forward	Intending to continue research with postgraduate students
Research and development of advanced receiver structures for application in high data rate indoor radio channels	Carried forward	Intending to continue research with postgraduate students
Spreading sequences and signature waveform design	Carried forward	Intending to continue research with postgraduate students
Testbed development	December 2005	On hold due to lack of appropriate resources

Research Planning & Activities

The main direction of the sub-projects has remained unchanged. For example, radio link adaptation, joint equalisation and decoding, advanced receiver structures have been carried forward from previous years. However, the project has excluded the practical implementation aspects. This is mainly due to a lack of resources to build a working demonstrator and also because of the unclear commercial benefits of such a development.

The departure of the project leader Professor Hans-Jürgen Zepernick has initialised a close relationship with Blekinge Institute of Technology in Sweden. Furthermore, supervisory arrangements are in place to secure

the supervision of ATcrc students. The project under its new project leader, Dr Manora Caldera, has been able to be sustained and developed. However, at the current time, no new areas are expected to be exploited. The future direction of the project will involve Dr Bijan Rohani, the new Program Director of the Wireless Program at WATRI.

Research Collaboration

The project team is actively involved in paper reviewing for major international conferences. There is continued contact with Professor Zepernick at Blekinge Institute of Technology in Sweden.

Initiatives and Breakthroughs

The year saw a number of student prize winners from the Project. In particular, PhD student Mr Behrooz Rohani won the IEEE Excellent Paper Award at the International Symposium on Wireless Communication Systems for the paper “Application of a perceptual speech quality metric for link adaptation in wireless systems”.

Intellectual Property

- MATLAB routines for software channel simulation
- MATLAB routines for soft-decision decoding and soft-combining of block codes
- MATLAB routines for equalization of wireless indoor channels

7.4 Communications Electronics Research Program

Overview

The integration of circuits, optical devices and computer systems with faster transmission systems, lower signal levels and denser circuit boards has made managing signals in electronic switching systems critical. Greater emphasis is now placed on managing problems relating to signal integrity, timing and cross-talk. The control of non-linear responses in optical devices is also critical for high-speed communication.

Technology Context

Erbium Doped Fibre Amplifiers (EDFAs) have revolutionised high data rate optical communications systems. The ability to simultaneously amplify a number of optical signal channels in a single fibre has made the EDFA a core enabling technology for Wavelength Division Multiplexed (WDM) systems and Dense WDM (DWDM). These systems now form the backbone of terrestrial communications networks.

Impairments suffered by timing signals play a critical role in modern electronic systems. Identifying the mechanisms that contribute most to timing impairments and to developing models suitable for predicting performance is a key objective in this project.

Progress against Contractual Milestones/Targets

Sub-Project 1: OptoElectronic Systems: Erbium Doped Fibre Amplifiers (EDFA)

Description of Milestones	Milestone Date as per Commonwealth Agreement	Achievement Date (or proposed achievement date if milestone not met)
Theory of current and new EDFA control techniques	End of Q4 2004	Adjusted to Q1 2005 and completed in Q2 2005.
Computer simulation studies	End of Q3 2005	Ongoing
Laboratory setup for transient response testing on the Altamar Amplifier	End of Q3 2004	Adjusted to Q4 2005 Completed Q2 2005
Implementation and Verification of the Altamar Amplifier	End of Q2 2006	Ongoing
Investigation of computational requirements	End of Q4 2004	Ongoing

Description of Milestones	Milestone Date as per Commonwealth Agreement	Achievement Date (or proposed achievement date if milestone not met)
Computer Simulation	End of Q4 2005	Ongoing
Stratix PCI Card hardware/software environment	End of Q1 2006	Ongoing
Second Altamar Optical Amplifier System	End of Q2 2005	Completed end of Q4 2004

Sub-Project 2: Timing Impairments in Electronic Systems (Clock Jitter in CMOS)

Description of Milestones	Milestone Date as per Commonwealth Agreement	Achievement Date (or proposed achievement date if milestone not met)
Identification of an application to demonstrate "minimum jitter point" – (an oscillator or VCO)	End of Q3 2004	The digital transceiver system chosen adequately predicted the performance obtainable in a practical realisation. Consequently, the two other project milestones were not required.
Experimental setup	End of Q3 2004	No longer required
Experimental measurements/validation	End of Q4 2004	No longer required

Sub-Project 2: Timing Impairments in Electronic Systems (Metastability)

Description of Milestones	Milestone Date as per Commonwealth Agreement	Achievement Date (or proposed achievement date if milestone not met)
Experimental setup Mathematical look at measuring metastability Investigate the various experimental methods proposed in the literature Characterise the chosen measurement system	End of Q4 2004	Complete
Measurements and validation Measure the metastable performance of several DFFs and synchronisers Compare different logic families Consider the effect of power supply on metastability Extraction of metastability parameter from the measured delay histograms	End of Q4 2004	Complete

Research Collaboration

Continued interaction with established industry contacts resulted in the donation of $15,000 worth of laboratory infrastructure to the Program. This allowed the verification of research findings and the development of prototype systems using the latest devices.

Both sub-projects suffered the loss of key staff members. To accommodate these departures, the Program was restructured around the EDFA sub-project. A PhD student was seconded to work on the project and will remain until the wind down of CRC research activities in December 2005.

Research Planning & Activities

OptoElectronic Systems: Erbium Doped Fibre Amplifiers (EDFA)
The operational integration of a second Altamar optical amplifier constituted the completion of a major milestone.

Resources within the program were restructured around two components:

1) The development of new EDFA control architectures based on an understanding of the factors governing the generation and dynamic control of gain transients in EDFAs. The performance of selected control algorithms will be validated on the programmable EDFA platform donated by Altamar.

2) A study of FPGA-based hardwired hardware realisations for EDFA control algorithms. The study involves research into the mapping of control algorithms into hardware that supports fixed point operations. The performance of the fixed point algorithms will be initially assessed using the Matlab-Stratix environment developed previously in the Program.

Four EDFA control algorithms were selected as candidates for verification on the Altamar optical amplifier hardware platform. Preliminary experimental observations were made of the transient performance of the closed-loop system for each of the algorithms.

Timing Impairments in Electronic Systems

Clock Jitter in CMOS

A new suite of Matlab scripts was written to provide a direct comparison between measured results, the analytical mode and PSPICE, an implementation of SPICE - Simulation Program with Integrated Circuit Emphasis - that runs on a PC for doing circuit simulation studies. New jitter measurements were made to help validate the analytic model. The magnitude of the jitter can now be predicted.

Metastability

Experiments were conducted on D type flip-flops from different manufacturers. These measurements revealed the existence of marked differences in metastability performance across manufacturers and devices. It was observed that the variation between each flip-flop type is due to the technology speed.

The project was wound down in March 2005.

Initiatives and Breakthroughs

The Program has been restructured with sub-project 4.2 (timing impairments) being wound-up due to staff loss. The remaining sub-project 4.1 is on track to achieve its milestones.

8 Education and Training

8.1 Overview

As the Education Program has matured over the last six years, post-graduate student completion has become a significant component of student activities. The 2004/2005 period saw the completion of ATcrc's Vacation Student Scheme and the postgraduate research student Top-up Scholarship Program. Conference organisation activities have expanded from the CRC's own annual conference and continued assistance in the organisation of ATNAC, to the IEEE Region 10 Conference (Tencon'05), the IEEE Vehicular Technology Conference (VTC-Spring 2006), and the IEEE Asia-Pacific Conference on Communications (APCC 2005). The IPv6 Course continued to be well-received in the industry community.

8.2 Initiatives and New Approaches

Education Showcase

In lieu of an Annual Review, ATcrc held an Education Showcase for the industry and academic public. Held in Melbourne as part of the Australian Innovation Festival, the Showcase featured a presentation from ATcrc Board Member and Research Director Professor Tony Cantoni entitled "University Research – Where are we headed?" A selection of students also presented their research.

The Australian Telecommunications Networks and Applications Conference

The success of ATcrc's re-initiation and organisation of ATNAC 2003 led to staff participation in the organisation of ATNAC 2004, hosted by the Smart Internet Technology CRC in Sydney. ATNAC 2005 will be a technical co-sponsor of Tencon'05. ATcrc staff are key members of the Tencon'05 organisation committee.

8.3 Ongoing Activities throughout the Year

Staff Changes

Sarah Craze, Education and Marketing Manager, was relocated to Melbourne in late July 2004. Her employment is contracted from Capital Technic Consulting.

Training Courses

"Introduction to IPv6 Protocols" continued to be popular, with presentations given to Telstra Research Laboratories in Launceston and to a collection of regional Victorian representatives in Ballarat. Restructuring of the course material for inclusion in a collective training environment is being considered.

Student Progress

The 2004/2005 period saw eight students complete their postgraduate degrees, with three pending acceptance. Currently, 44 students are working in ATcrc's research programs, with 24 receiving top-up scholarships and two students seconded to industry activities.

No new top-up scholarships will be offered in the future. However, ATcrc is committed to funding current top-up scholarships beyond the CRC's completion in June 2006. The Education Program anticipates a high number of student submissions in the next year.

2004 Vacation Scholarships Scheme

Three Vacation Scholarships were offered to penultimate year students at each of our five University nodes. We were pleased to increase the number of scholarships at RMIT University to incorporate the two very different research programs located there. The winners of the best Vacation Student presentations were Mark Spoelstra from Victoria University (*Video streaming interface for the Tait STAR platform*) and Mark Evans from the University of Western Australia (*EDFA pump laser drive current limiter electronics*).

The 2004 Vacation Scholarships Scheme was the last time the Scheme was offered to undergraduate students. The scheme has been exceptionally well received by undergraduate students at our nodes over the years. It has attracted high quality students and is considered a prestigious and desirable addition to graduate CVs. Five vacation students have continued on as PhD students in ATcrc.

4th ATcrc Conference and Workshop

The fourth ATcrc Conference was held on 13 December 2004 at the Old Swan Brewery in Perth, WA. Twenty-four staff and students flew over from Melbourne and the number of attendees totalled 45. This year's invited speaker was Dr John Siliquini of Xelor Software, who spoke about the challenges of commercialising research and creating a marketable product. Dr Caspar Ryan also gave a presentation of his project, *Frameworks for the Development of Next Generation Internet Applications*.

The oral presentation prize was won by Matthew Williamson of Victoria University, and the poster prize was shared between Behrooz Rohani of WATRI (*GSM power control using a perceptual speech quality metric*) and Suyong Eum of RMIT (*TomoKruithof vs Tomogravity for backbone networks*).

This year's Workshop was formed in response to the Fifth Year Review. Mrs Pieta O'Shaughnessy of Curtin FM gave a half-day seminar covering presentation and media skills. All participants prepared a short statement of their research and acted as either an interviewer or interviewee. They were also expected to give a five minute presentation that would "sell" their research to a panel of potential investors. The seminar was well received by the participants.

The afternoon session was given to Mr Steven Starkie of Griffith Hack and ATcrc's patent attorney. Mr Starkie spoke about procedures for patenting research and participated in an animated question and answer session. The rest of the afternoon was given to the Perth *vs* Melbourne Quiz. Participants all enjoyed the opportunity to work together with their colleagues on something other than their research for a change!

Attendance at the Conference has dropped from previous years. We felt that this is primarily because the number of CRC staff and students has decreased, not because people were not interested in attending. We felt that 80% of CRC staff and students were in attendance, so networking opportunities were still significant. The final ATcrc Conference will be held in Melbourne in November 2005.

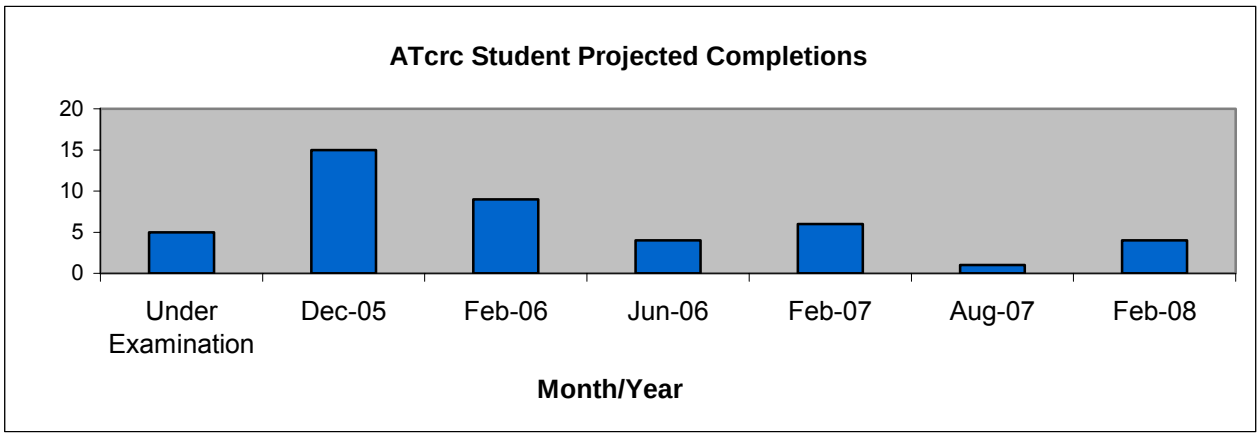
Challenges and Problems Experienced

The departure of a number of key staff caused supervisory reshuffling within ATcrc. Some students decided to continue their studies elsewhere. We are pleased to report that most students affected by the departure of their supervisor have elected to continue within ATcrc.

Future Directions

ATcrc's role in external conference organisation has increased significantly since *ATNAC 2003*. Organisational involvement exists within *Tencon'05, APCC 2005, VTC-Spring 2006*, and the *2006 Australian Communication Theory Workshop*.

The Education Program will also concentrate on commercialisation opportunities for the "Introduction to IPv6 Protocols" workshop and other training opportunities in development.



8.4 ATcrc Alumni as at 30 June 2005

Mr D.T. Tantiprasut (PhD), Integration of the Internet Protocol and ATM Routing and Quality Services, Curtin University of Technology, Dec 1999. Supervisor: Dr C.A. Farrell. Joined NDG Software, San Diego, USA, now known as Network Harmoni. He is the Chief Software Architect.

Mr K.H. Chen (PhD), Performance Study of Data Transfer over Wide-Area ATM Network using UBR Services with Packet Discard, Curtin University of Technology, Feb 2000. Supervisor: Prof Z.L. Budrikis. Joined Nexion Fujitsu, Boston, USA.

Mrs B.J. Wysocki (PhD), Signal Formats for Code Division Multiple Access Wireless Networks, Curtin University of Technology, Feb 2000. Supervisor: H.-J. Zepernick. Currently a part-time Research Fellow at the University of Wollongong.

Mr S.A. Ivandich (PhD), Performance Analysis of Adaptive Arrays with Projected Perturbation Sequences, Curtin University of Technology, May 2000. Supervisor: Prof A. Cantoni. Joined ATcrc's UWA node and is now a Senior Network Engineer with the Xelor Software team.

Mr H.T. Ong (PhD), Bootstrap Methods for Signal Detection, Curtin University of Technology, Jun 2000. Supervisor: Prof A.M. Zoubir. Joined DSTO Salisbury, Australia.

Mr C.L. Brown (PhD), Nonparametric Detection and Classification of Signals in the Presence of Non-Gaussian Noise, Curtin University of Technology, Jul 2000. Supervisor: Prof A.M. Zoubir. Joined Chalmers University, Sweden, as a Research Fellow, now at Technical University of Darmstadt, Germany.

Mr C.H. Tseng (PhD), Iterative Algorithms for Envelope-Constrained Filter Design, Curtin University of Technology, Jul 2000. Supervisor: Prof K.L. Teo. Joined Weierstrass Institute, Berlin Germany. Now a Research Fellow in the Electrical & Electronic Division, University of Warwick, UK.

Mr J.D. Tuthill (PhD), Frequency Dependent Digital Compensation in DSP Based FM Modulators, Curtin University of Technology, Jul 2000. Supervisor: Prof A Cantoni. Joined ATcrc's Communications Electronics Program at WATRI, now with QR Sciences Limited, WA (2005).

Ms H.H. Dam (PhD), Hardware Efficient Optimal FIR Digital Filters, Curtin University of Technology, Feb 2001. Supervisor: Prof K.L. Teo. Joined ATcrc's Wireless Program at WATRI. Now employed as a Research Fellow at WATRI.

Mr M.R. Morelande (PhD), Estimation, Detection and Model Selection of Random Amplitude Polynomial Phase Signals, Curtin University of Technology, May 2001. Supervisor: Prof A.M. Zoubir. Joined the Department of Electrical and Electronic Engineering at the University of Melbourne as a Research Fellow.

Mr A. Sanyal (Masters), Topic unknown, Monash University, Feb 2002. Supervisor: Dr R. Nelson. Whereabouts unknown.

Ms N. Abdulaziz (PhD), Digital Watermarking and Data Hiding in Multimedia, Monash University, Mar 2002. Joined the Department of Electrical and Computer Systems Engineering, Monash University, as a Research Associate.

Mr K.N. Le (PhD), Parallel Computation of Higher Order Spectrum, Monash University, Jun 2002. Supervisor: Prof G.K. Egan. Joined Griffith University.

Ms H. Zhou (PhD), Provision of Non-Realtime Services over ATM Networks, Curtin University of Technology, Aug 2002. Supervisor: Dr G. Mercankosk. Joined Genista Research Pte Ltd, Singapore and now a Lecturer at the University of Southern Queensland.

Mr P. Tissainayagam, (PhD), Visual Tracing in Image Sequences, Monash University, 2002. Supervisor: Prof G.K. Egan. Joined the Digital Perception Laboratory, Monash University.

Mr M.T. Green (PhD), Time Varying Non-linear System Identification, Curtin University of Technology, Aug 2002. Supervisor: Prof A.M. Zoubir. Joined ATcrc Curtin node Wireless Program. Currently travelling around Australia.

Mr B.K. Lau (PhD), Applications of Adaptive Antennas in Third-Generation Mobile Communications Systems, Curtin University of Technology, Jul 2003. Supervisor: Dr Y.H. Leung. Joined the Department of Telecommunications and Signal Processing, Blekinge Institute of Technology, Sweden. Now with Lund University, Sweden.

Mr B. Jiao (PhD), Signal Set Design for Telecommunication Systems, Curtin University of Technology, Jul 2003. Supervisor: Prof S.E. Nordholm. Now a Research Fellow at the Chinese Academy of Science in Beijing.

Mr R.F. Brcich (PhD), Design of Optimal Satellite Communications Receivers in Non-Gaussian Interference, Curtin University of Technology, Jul 2003. Supervisor: Prof A.M. Zoubir. Joined the Technical University of Darmstadt, Germany.

Mr A. Stocjevski (PhD), A Reconfigurable Analog-to-Digital Converter for a Mobile Receiver, Victoria University, Aug 2003. Supervisor: Prof M. Faulkner. Now a Lecturer at Victoria University.

Mr C. Kit-Opas (Masters) MLD + Mobility. Monash University, Sep 2003. Supervisors: Dr R. Nelson & Dr Y.A. Sekercioglu. Whereabouts unknown.

Mr L. Huang (PhD), Blind Adaptive Multiuser Detection for Multirate DS/CDMA Systems, Victoria University, Oct 2003. Supervisor: Dr F.-C. Zheng. Currently with the Department of Electrical and Computer Engineering, National University of Singapore.

Mr K.J. Winchester (PhD), Tunable Microelectromechanical Fabry-Perot Filters Using Plasma Enhanced Chemical Vapor Deposited Silicon Nitride Membranes, University of Western Australia, Dec 2003. Supervisor: Dr J. Dell. Now a Senior Research Fellow (Microelectronics Research Group) at University of Western Australia.

Mr J. Gao (PhD), Equalisation for Carrierless Amplitude and Phase Modulation, Curtin University of Technology, Jan 2004. Supervisor: Dr Y.H. Leung. Joined the ATcrc Adaptive Antennas project, now with Telstra Research Laboratories, Melbourne (2004).

Mr G. Cook (Masters), Direction of Arrival Estimation with Microphone Arrays in a Reverberant Environment, Curtin University of Technology, Feb 2004. Supervisor: Dr Y.H. Leung. Joined PNDT (Pilbara Non-Destructive Testing) Pty Ltd, Perth WA.

Mr R. Chellappa-Doss (PhD), Prediction-based Location Aided Routing (P-LAR) Protocol, RMIT University, Feb 2004. Supervisor: Prof A Jennings. Employed as a Lecturer at Deakin University, Melbourne.

Mr C. Voo (PhD), Traffic Management of Low and Variable Bit Rate Traffic incorporating ATM Adaptation Layer type 2, University of Western Australia, Apr 2004 Supervisor: Dr J Siliquini. Employed by an online stock broking company.

Mr T.-D. Tomlin (PhD), Analysis and Modeling of Jitter and Phase Noise in Electronic Systems: Phase Noise in RF Amplifiers and Jitter in Timing Recovery Circuits, University of Western Australia, May 2004. Supervisor: Prof A. Cantoni. Joined ATcrc's Communications Electronics Program at WATRI.

Mr A. Kist (PhD), Methodologies to Enable QoS Signalling in 3GPP IP Multimedia Subsystem SIP-based Networks, RMIT University, May 2004. Supervisor: Prof R Harris. Joined ATcrc's Networking Program at RMIT.

Mr J. Huo (PhD), Subband Acoustic Echo Cancellation, Curtin University of Technology, May 2004. Supervisor: Prof S. Nordholm. Joined Hong Kong University, China.

Ms P. Fardipur (Masters), Intelligent Routing for 4th Generation All-IP Cellular/Wireless Networks, Monash University, Jun 2004. Supervisor: Dr Y.A. Sekercioglu. Currently working part-time at Monash University as a lab supervisor.

Mr D. Chandra (PhD) *The Enhanced Transport Protocol for Wireless Internet*. RMIT University. Supervisor: Prof R. Harris, August 2004. Now employed by Deakin University.

Mr H. Tran (PhD) *Multicast Routing with Source-to-Destination Delay and Inter-destination Delay Variation Constraints*. RMIT University. Supervisor: Prof R. Harris, September 2004. Now with the Department of Switching Technology, Research Institute of Post and Telecoms, Hanoi, Vietnam.

Mr J. But (PhD) *A Novel MPEG-1 Partial Encryption Scheme for the Purposes of Streaming Video*. Monash University. Supervisor: Prof G. Egan, October 2004. Joined Swinburne University of Technology, Melbourne.

Mr J.M. Lok (Masters) Intelligent control structures for mobile IPv6 networks. Monash University. Supervisor: Dr Y.A. Sekercioglu, October 2004. Continuing as a PhD student at Monash University.

Mr E. Wu (Masters) Dynamic topology partitioning for parallel simulation of large-scale mobile IPv6 networks. Monash University. Supervisor: Dr Y.A. Sekercioglu, October 2004. Continuing as a PhD student at Monash University.

Mr C. Watagodakumbra (PhD) *Packet Scheduling in DiffServ Environment*. RMIT University. Supervisor: Prof R. Harris, January 2005. Joined Peninsula School of Computing and Information Technology, Monash University (Peninsula).

Mr I.D. Holland (PhD) Adaptive Coding Schemes utilising Long Term Channel Prediction Algorithms. Curtin University. Supervisor: Prof H.-J. Zepernick, June 2005. Employed by ATcrc as a Research Fellow on the Radio Access Technologies Project.

Mr T. Nguyen (PhD) *Capacity Improvement Using Adaptive Sectorisation in WCDMA Cellular Systems with Non-Uniform and Packet Mode Traffic*. Victoria University. Supervisor: Prof P. Dassanyake, November 2004. Currently seeking a position.

8.5 Postgraduate Student List as at 30 June 2005

N.B.: "Name Withheld" refers to ATcrc students who preferred not to have their name included in the Annual Report.

Curtin University of Technology

Name	Degree	Topic and ATcrc Project
Abd el Sallam, Amar	PhD	Low Order Channel Estimation for CDMA Systems (3)
Davis, Alan^	PhD	Speech Enhancement Models (3.3)
Day, Greg†	PhD	Receiver Structures for High Speed Wireless Data Communications (3.3)
Kusuma, T. Maulana†	PhD	Performance Characterization of Radio Transmission Technologies Based on Objective Quality Measures (3.3)
Low, Siow Yong*	PhD	Speech Enhancement Using Microphone Array (3.3)
Pham, Son Duc†	PhD	Adaptive Signal Detection in Unknown Noise Multiple Access Channels (3)
Wahab, Mashury	PhD	Multi-user Detection for Multi-carrier CDMA Systems (3)
Name withheld	PhD	Applications of Antenna Arrays in Multicarrier CDMA Systems (3)

Monash University

Name	Degree	Topic and ATcrc Project
Belhoul, Ahmad	MEng	Scalability Analysis of Mobility Protocols for All-IP Mobile/Cellular Networks (1.1)
Kurup, Gopi†	PhD	IPv6 Source Specific Multicast (1.1)
Lai, Johnny Man Lok†	PhD	Intelligent Control Structures for Mobile IPv6 Networks (1.1)
Moore, Nick	MEng	Ad-Hoc Networks (1.1)
Pham, Duc†	MEng	Quality of Service for Wireless Local Area Networks (1.1)
Sivahumaran, Thirukkumaran†	PhD	Space-time Communications (3)
Wu, Eric	PhD	Optimization of Communications between Two Moving End Hosts in Mobile IPv6 (1.1)
Name withheld	PhD	Networks in Motion (1.1)
Name withheld	MEng	Simulation of LSP failures in MPLS Networks for Traffic Engineering (1.1)
Name withheld	MEng	Efficient Congestion Control for All-IP Mobile/Cellular Networks (1.1)
Name withheld	PhD	Mobility Management of Wireless Local Area Networks (1.1)
Name withheld	MEng	Fuzzy Logic-based QoS Routing Algorithms (1.1)

RMIT University

Name	Degree	Topic and ATcrc Project
Citro, Sandy†	PhD	Framework for Mobile Real-Time Collaborative Work (1.2)
Eum, Suyong†	PhD	Advanced Technologies for Estimating Traffic Intensities in IP Networks (2.1)
Suryasaputra, Robert†	PhD	Congestion Control in the Future Internet Network (2.1)
Venkatachalaiah, Suresh†	PhD	Handoff and Mobility Prediction in Cellular Systems, Performance and Analysis (2.1)
Name withheld	PhD	TCP Congestion Management (1.2)

University of Western Australia

Name	Degree	Topic and ATcrc Project
Cresp, Gregory†	PhD	A Mathematical Framework for Designing Spreading Sequences with Low Correlation Zones (3.3)
Doan, John	MEng	Design, Modelling and Implementation of a Burst-Mode, All Optical Switched, WDM Network (4.1)
Griffiths, Wayne†	PhD	APP Decoding of Non-binary Product Codes over Discrete Channels (3.3)
Males, Mladen^	PhD	Suppression of Transient Gain and Power Excursions in Erbium-doped Fibre Amplifiers (4.1)
Rohani, Behrooz†	PhD	Multimedia Communication in Wireless Systems using Objective Perceptual Quality Measures (3.3)
Schweizer, Andreas†	PhD	TBA (4.1)
Shaheem, Asri†	PhD	Advanced Link Adaptation Techniques for Mobile Radio Systems (3.3)
Wijaya, Shierly†	PhD	TBA (4.1)
Name withheld	PhD	Enabling Real-time Transfers over IP Networks (4.1)
Name withheld	PhD	Analysis of Power Ground Planes in Multi-layered Printed Circuit Boards (4.1)
Name withheld	PhD	Maintaining QoS Guarantees for Mobile Devices requiring Real-Time Services over IP Networks (4.1)

Victoria University

Name	Degree	Topic and ATcrc Project
Alamgir, Mohammed†	PhD	TBA (3.2)
Fitrio, David†	PhD	Power management chip for ultra low power portable wireless devices (3.2)
Lebrun, Guillaume *	PhD	Performances of MIMO Wireless Communication Systems (3.2)
Williamson, Matthew †	PhD	Adaptive Integrated Transmitter Receiver (3.2)
Name withheld	PhD	Power Management for Reconfigurable Wireless Logic (3.2)
Name withheld	PhD	Adaptive Duplexer for Software Radio (3.2)
Name withheld	PhD	Capacity/PILOT Overhead Trade Off for MIMO Systems (3.2)
Name withheld *	PhD	Channel Estimation for OFDM Systems with Transmitter Diversity (3.2)

Legend

† Top-up scholarship recipient

* Thesis under examination

^ On industry secondment

9 Collaboration

9.1 External and International Linkages

Dr Leith Campbell
Gave a presentation to the 7th Australian Research and Development Summit in Sydney, 20-21 September 2004, entitled "Telecommunications Innovation: transferring knowledge through R&D expertise."
Member of the Tencon'05 Organising Committee and Chair of ATNAC 2005 within Tencon.
Chair, World Telecommunications Congress Council and interim Chair, International Technical Committee.

Dr Manora Caldera
Reviewed papers for the 2005 Asia-Pacific Conference on Communications.

Mr Greg Daley
Chaired Detecting Network Attachment Working Group at the IETF Meeting, San Diego USA, August 2004.
Chaired Detecting Network Attachment Working Group at the IETF Meeting, Washington USA, November 2004.
Chaired Detecting Network Attachment Working Group at the IETF Meeting, Minnesota USA, March 2005.

Dr Heidi Dam
Chaired session on Application of optimisation for signal processing and wireless I and II at the 2004 International Conference on Optimisation Techniques and Applications.

Dr Jason Gao
Attended STAR meeting at Tait Electronics and presented the IEEE 802.11n proposal, November 2004.

Prof Michael Faulkner
On leave for an Outside Study Program from July 2004 – February 2005 at Lund University and Ericsson Mobile Platforms, Sweden.
Visited Ericsson A/B, NanoRadio, KTH and Mitsubishi Research, Boston.
Attended the IEEE 802.11 standardisation meeting in Atlanta, USA, 14 - 18 March 2005.
Attended and presented at the IEEE 802.11 standardisation meeting in Cairns, May 2005.

Mr Daniel Grimm
Gave a presentation to the AUC study tour about IPv6 and video streaming.

Prof Richard Harris
Presentations of the OptiFlow Project to Allen & Buckeridge and Kaz Consulting.

Dr Ian Holland
Invited presentation on "Performance analysis of adaptive QAM schemes with non-zero delay" at Australian Communications Theory Workshop in Brisbane, 2-4 February 2005.
Reviewed papers for the 2005 Asia-Pacific Conference on Communications.

Dr Alexander Kist
Collaborations with Telstra Research Laboratories concerning OptiFlow project benchmarking.

Dr Scott Leyonhjelm
Attended and presented at the IEEE 802.11 standardisation meeting in San Antonio, USA, November 2004.
Attended and presented at the IEEE 802.11 standardisation meeting in Cairns, May 2005.
Planning and strategy meetings with Wavebreaker AB, Sweden (September 2004).
Met with Infineon Ventures, Berlin regarding potential investment in the ATcrc/Wavebreaker joint venture (September 2004).
Met with Nanoradio AB, Stockholm - a potential customer for the silicon intellectual property developed by the ATcrc/Wavebreaker joint venture (September 2004).
Visited Ericsson AB with regard to initiating the sale of the Wavebreaker FPGA-based development platform. (September 2004).

Mr Nick Moore
Gave presentations on Edge Handovers research work and Optimistic DAD at the IETF Meeting, San Diego USA, August 2004.

Dr John Murphy
Presentations of the OptiFlow Project to Allen & Buckeridge and Kaz Consulting.

Prof Sven Nordholm
Chaired a session at the 2004 International Symposium on Intelligent Multimedia, Video and Speech Processing.
Technical Program Chair of 2005 Asia Pacific Conference on Communications, Perth WA, October 2005.
Invited presentation at Blekinge Institute of Technology, Sweden.
Invited presentation at the Hands-free Workshop at Rutgers University in Piscataway, New Jersey.
Visited NTT in Kyoto Japan.
Visited Texas Instruments, Dallas USA.
Reviewed papers for the 2005 Asia-Pacific Conference on Communications.

Mr Erik Östlin
Gave a presentation on the CDMA Scanner work to Telstra Research Laboratories Melbourne.
Gave a presentation on the CDMA Scanner work to Blekinge Institute of Technology, Sweden.

Mr Brett Pentland
Delivered the IPv6 Course at the Ballarat Innovation Festival.
Gave a presentation on the Link ID draft at the IETF Meeting in Washington USA, November 2004.
Gave a presentation on the Link ID draft at the IETF Meeting in Minnesota USA, March 2005.
Presented IPv6 Handover research seminar at Swinburne University of Technology.

Dr Ahmet Sekercioglu
Presented IPv6 Simulation seminars to Infotek Systems, Taipei University and the Taiwan IPv6 Forum, Taiwan, August 2004.
Presented IPv6 Simulation seminar to Samsung Advanced Institute of Technology, Korea, August 2004.
Presented IPv6 Simulation seminar at University of Waikato, New Zealand, September 2004.

Prof Hans-Jürgen Zepernick
Chaired session on Spreading Sequences I at the 2004 IEEE International Symposium on Spread Spectrum Techniques and Applications.
Chaired sessions on Wireless LAN at the IEEE International Symposium on Wireless Communication Systems.

Prof Fu-Chun Zheng
Visited British Telecom, Sept-Dec 2004.

9.2 Collaboration with other CRCs

ATcrc had a collaborative research agreement, signed June 2003, with Australian Photonics Pty Ltd for the Australian Photonics CRC. This envisaged collaborative research on management of optical networks and potential commercialisation. The agreement was terminated in 2004/2005 after Australian Photonics Pty Ltd went into voluntary administration and it was clear that the final payment to ATcrc would not be made.

ATcrc and the Smart Internet Technology CRC (SIT-CRC) collaborated on the organisation of *ATNAC* 2004 in Sydney and are continuing to collaborate on future *ATNAC* conferences. ATcrc and SIT-CRC are also in discussion over a future collaborative research project.

ATcrc's CEO is a member of the Council of ICT CRCs.

10 Specified Personnel

A key strength in Commonwealth Cooperative Research Centres is the combined expertise of highly skilled staff focused on common goals. ATcrc draws together a diverse and highly skilled staff across six locations in three states – CSIRO ICT Centre in Sydney; Monash University, RMIT University and Victoria University in Melbourne; and the University of Western Australia (UWA) and Curtin University of Technology in Perth. Staff from research, commercialisation and administrative areas share their expertise and are united by a common mission that ensures that collectively ATcrc is greater than its parts.

Departures and New Additions

There were several changes to the CRC's senior management during the year.

- Dr Khee Pang at Monash resigned as Applications Program Research Executive in August 2004 and was replaced by Professor Greg Egan;
- Professor Hans-Jürgen Zepernick left Curtin/WATRI in December 2004 and resigned as Associate Director, Program Leader for the Wireless Program, and Project Leader for the Radio Access Technologies project;
- Dr Manora Caldera at WATRI replaced Professor Zepernick as Program Leader for the Wireless Program;
- Professor Richard Harris left RMIT in February 2005 and resigned as Associate Director and Networking Program Research Executive;
- The contract for Dr John Murphy, Project Leader for the Networking Program's Dynamic Management of Advanced Networks project, expired in December 2004 and was not renewed.
- Professor Antonio Cantoni was re-engaged by the Communications Electronics Program on an in-kind basis.
- Professor Gregory Egan was elected an Associate Director from April 2004.

Associate Directors

Associate Directors are appointed by the Board. They assist the CEO in managing the Centre. Associate Directors Professor Hans-Jürgen Zepernick and Professor Richard Harris left ATcrc in the 2004/2005 period. As at 30 June 2005, ATcrc had one Associate Director, Professor Gregory Egan. A second Associate Director is currently being sought.

Executive Research Committee

The Executive Research Committee is made up of the CEO, Associate Directors, the Programs' Research Executives and industry representatives. Its purpose is to review the overall direction and quality of ATcrc's activities, including review of agreed performance indicators. The Committee acts in an advisory capacity to the CEO.

At 30 June 2005, the Executive Research Committee, in addition to representatives from each industry partner, had the following academic members:

Name	Organisation	Role in Centre
Dr Leith H. Campbell	ATcrc	CEO
Professor Greg Egan	Monash	Associate Director Applications Program Research Executive Education Program Executive
Professor Kevin Fynn	WATRI	Communications Electronics Program Research Executive
Professor Sven Nordholm	Curtin	Wireless Program Research Executive

Specified Personnel

The agreement with the Commonwealth (schedule 5) requires ATcrc to support "specified personnel". These are people in key leadership roles. The table below details the "Specified Personnel" in key roles in ATcrc together with their institutional affiliation, position and actual percentage of time devoted to Centre activities.

Title/Name	Contributing Institution	% time in CRC	Role in ATcrc
Dr Leith Campbell	ATcrc	100	Chief Executive Officer
Professor Antonio Cantoni	WATRI	50	Board Member
Professor Sven Nordholm	Curtin	70	Research Executive
Professor Greg Egan	Monash	57.5	Associate Director
Professor Kevin Fynn	WATRI	70	Research Executive
Professor Richard Harris	RMIT University	17.5	Assoc. Director/left Feb 2005
Dr Leung Yee Hong	Curtin	10	Program Leader
Dr Ahmet Şekercioğlu	Monash	44.17	Program Leader
Professor Hans-Jürgen Zepernick	Curtin	60	Assoc. Director/left Dec 2004
Professor Mike Faulkner	Victoria University	65	Project Leader
Dr John Murphy	RMIT University	45	Program Leader/left Dec 2004
Dr Hajime Suzuki	CSIRO	3.06	Project Leader

11 List of Publications and Patents

11.1 Patents

I. Tolchoko, **M. Faulkner**, Channel Estimation for Orthogonal Frequency Division Multiplexing Systems. US Patent Number PCT/AU2004/001704

For maintained patents, see section 11.9 below.

11.2 Book Chapters

S. Nordholm, **H.-J. Zepernick**, "Modulation and detection." *in Electrical Engineering, K.P. Wong (ed.) in Encyclopaedia of Life Support Systems (EOLSS) developed under the auspices of the UNESCO*, EOLSS Publishers, Oxford, UK, 2005.

Y.H. Leung, B.K. Lau, "Signals and systems." *in Electrical Engineering, K.P. Wong (ed.) in Encyclopaedia of Life Support Systems (EOLSS) developed under the auspices of the UNESCO*, EOLSS Publishers, Oxford, UK, 2005.

Y.J. Guo, **F.-C. Zheng**, "Multiple antennas" Chapter 5, in *Advanced Technologies in Radio Access Networks*, by Y.J. Guo, London: Artech House, 2004.

11.3 Journal Articles Published

Leith Campbell, "Telecommunications in a social context", book review, *Telecommunications Journal of Australia*, vol. 54, no. 2, Winter 2004, p. 29.

Leith Campbell, "ATNAC returns to support telecommunications research and development in Australia". *Telecommunications Journal of Australia*, vol. 54, no. 1, Autumn 2004, pp. 59-60.

H.H. Dam, **S. Nordholm**, **A. Cantoni**, J.M. de Haan, "Iterative method for the design of DFT filter bank." *IEEE Transactions on Circuits and Systems II, IEEE Transactions on Circuits and Systems II,* vol. 51, no. 11, pp. 581-586, Nov. 2004.

H.H. Dam, **H.-J. Zepernick**, **S. Nordholm**, "Spreading code design using a global optimisation method." *Annals of Operations Research 133,* pp. 249-264, 2005.

G. Day, **S. Nordholm**, **H.H. Dam**, "Optimized decision delays in finite-length MIMO DFE." *IEEE Signal Processing Letters*, No. 5, Vol. 12, May 2005, pp. 391-395.

L. Huang, **F.-C. Zheng**, "Space-time blind multiuser detection for multirate DS/CDMA signals." *IEEE Transactions on Vehicular Technology*, vol. 53, no. 6, November 2004, pp. 1746-1755.

G. Lebrun, **J. Gao**, **M. Faulkner**, "MIMO transmission over time varying channel using SVD." *IEEE Transactions on Wireless Communications*, vol. 4, no. 2, 2003, pp. 757-764.

D.S. Pham, A. M. Zoubir, "A sequential algorithm for robust parameter estimation." *IEEE Signal Processing Letters*, vol 12, no. 1, January 2005, pp. 21-24.

J. Tuthill, **A. Cantoni**, "Efficient compensation for frequency-dependent errors in analog reconstruction filters used in IQ modulators." *IEEE Transactions on Communications*, vol. 53, no. 3, March 2005, pp: 489-496.

S. Venkatachalaiah, **R. J. Harris**, **R. Suryasaputra**, "Improvement of handoff in wireless networks using mobility prediction and multicasting techniques." *WSEAS Transactions on Communications*, vol. 4, no. 2, February 2005, pp. 104.

F.-C. Zheng, A.G. Burr, "Signal detection for orthogonal space-time block coding over time-selective fading channels: a PIC approach for the G_i systems. *IEEE Transactions on Communications*, vol. 53, no. 6, June 2005, pp. 969-972.

11.4 Journal Articles Accepted

C. Chrysostomou, A. Pitsillides, L. Rossides, **Y.A. Sekercioglu**, M. Polycarpou, "Congestion Control in Differentiated Services Networks using Fuzzy-RED." *IFAC Journal Control Engineering Practice.*

H.H. Dam, **S. Nordholm**, **A. Cantoni**, "Uniform FIR filter bank optimisation with group delay specifications." *IEEE Transactions on Signal Processing.*

B.K. Lau, **Y.H. Leung**, Y. Liu, K.L. Teo, "Transformations for non-ideal uniform circular arrays operating in correlated signal environments." *IEEE Transactions on Signal Processing.*

L. Rossides, C. Chrysostomou, A. Pitsillides, **Y.A. Sekercioglu**, A. Vasilakos, "Improving congestion control in DiffServ networks using Fuzzy-RED." *Computer Communications Journal,* Elsevier Science.

L. Rossides, C. Chrysostomou, **Y.A. Sekercioglu**, A. Pitsillides, "Fuzzy Logic controlled RED: Congestion Control in TCP/IP differentiated services networks." *Soft Computing Journal*, Springer-Verlag.

I. Tolochko, **M. Faulkner**, "Channel estimation in wireless LANs with transmitter diversity." *Wireless Personal Communications*.

R. Veljanovski, **J. Singh**, **M. Faulkner**, "Statistical analysis of adjacent channel protection factors for UTRA-TDD/FDD in a simulation environment." *Best of Book Journal,* AMSE Press.

Z. Zang, **S. Nordholm**, "Design of ODMA Digital Waveforms using non-convex optimisation method." *Annals of Operations Research.*

11.5 Conference Papers Published

A. Belhoul, **Y. A. Sekercioglu**, N. Mani, "A survey of QoS provisioning mechanisms in wireless All-IP networks." *Third Workshop on the Internet, Telecommunications and Signal Processing*, Adelaide, SA, December 2004, no pp. available.

M. Caldera, **H.-J. Zepernick**, **I.D. Holland**, C.-Z. Pui, S. van der Werf, “Unequal error protection schemes for image transmission over fading channels.” *IEEE International Symposium on Wireless Communication Systems*, Mauritius, September 2004, pp. 203 – 207.

C. Chrysostomou, A. Pitsillides, G. Hadjipollas, M. Polycarpou, **Y. A. Sekercioglu**, "Congestion control in differentiated services networks using fuzzy logic.” *43rd IEEE Conference on Decision and Control,* Paradise Islands, Bahamas, December 2004, vol.1, pp. 549-556.

L. A. Cirillo, A.M. Zoubir, M. Amin, "Direction finding of non-stationary signals using a time-frequency Hough transform.” *IEEE International Conference on Acoustics, Speech and Signal Processing*, Philadelphia PA, March 2005, vol. 4, pp. 501-504.

G. Daley, **B. Pentland**, "Pre-empting neighbour discovery in Mobile IPv6 handovers." *Australian Telecommunications, Networks and Applications Conference,* Sydney, December 2004, pp. 1-8.

G. Daley, **Y.A. Sekercioglu**, **G. K. Egan**, “Minimising authorisation delegation discovery delay in secured IPv6 router discovery.” *Third Workshop on the Internet, Telecommunications and Signal Processing*, Adelaide, SA, December 2004, pp. not available.

H.Q. Dam, **S. Nordholm**, **H. H. Dam**, **S. Y. Low**, "Adaptive beamformer for hands-free communication system in noisy environments.” *IEEE International Symposium on Circuits and Systems*, Kobe, Japan, May 2005, pp. 856-859.

H.H. Dam, **H.-J. Zepernick**, **S. Nordholm**, “On the design of complex-valued spreading sequences using a genetic algorithm.” *IEEE International Symposium on Spread Spectrum Techniques and Applications*. Sydney, August 2004, pp. 704-707.

H.H. Dam, **S. Nordholm**, **A. Cantoni**, **H.Q. Dam**, "Filter bank design with group delay approximations", *European Signal Processing Conference*, Vienna, Austria, September 2004, no pp. available.

A. Davis, **S.-Y. Low**, **S. Nordholm**, N. Grbic, "A subband space constrained beamformer incorporating voice activity detection." *IEEE International Conference on Acoustics, Speech and Signal Processing*, Philadelphia PA, March 2005, vol. 3, pp. 65-68.

G. Day, **S. Nordholm**, **H.H. Dam**, “Subband adaptive equalisation with optimised alignment delays.” *IEEE Global Communications Conference*, Dallas, Texas, November 2004, vol. 4, pp. 2292-2296.

A.A. El-Sallam, A. Zoubir, "Fast adaptive channel estimation algorithms for CDMA systems." *IEEE International Conference on Acoustics, Speech and Signal Processing*, Philadelphia PA, March 2005, vol. 3, pp. 933-936.

S. Eum, **J. Murphy**, **R. Harris**, "TomoKruithof vs Tomogravity for backbone networks.” *Australian Telecommunications Networks and Applications Conference*, Sydney, December 2004, pp. 108-112.

J. Foo, N. Mani, **Y.A. Sekercioglu**, "Restoration methods for bandwidth guaranteed paths in MPLS networks." *Third Workshop on the Internet, Telecommunications and Signal Processing*, Adelaide, SA, December 2004, pp. not available.

W. Griffiths, **H.-J. Zepernick**, **M. Caldera**, “On APP decoding of non-binary block turbo codes over discrete channels.” *International Symposium on Information Theory and its Applications*. Parma, Italy, October 2004, pp. 362-366.

I.D. Holland, **H.-J. Zepernick**, **M. Caldera**, “Performance of an adaptive QAM scheme over correlated Rayleigh fading with non-zero delay.” *IEEE Global Communications Conference*, Dallas, USA, November 2004, vol. 1, pp. 156-161.

A. Johannson, **S. Nordholm**, "Robust acoustic direction of arrival estimation using Root-SRP-PHAT, a realtime implementation." *IEEE International Conference on Acoustics, Speech and Signal Processing*, Philadelphia PA, March 2005, vol. 4, pp. 933-936.

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A.A. Kist, **R.J. Harris**, “Cost efficient overflow routing for outbound ISP traffic.” *Ninth IEEE Symposium on Computers and Communications*, Alexandria, Egypt, July 2004, vol. 2, pp. 876-882.

G. Kurup, **G. Daley**, **Y.A. Sekerciolgu**, “Improving multicast group management in the next generation mobile internet.” *Australian Telecommunications, Networks and Applications Conference*, Sydney, December 2004, pp. 433-436.

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T.M. Kusuma, **M. Caldera**, **H.-J. Zepernick**, “Utilising objective perceptual image quality metrics for implicit link adaptation.” *IEEE International Conference on Image Processing*, Singapore, October 2004, Vol. 4, pp. 2319-2322.

J.M. Lai, **E. Wu**, **Y.A. Sekercioglu**, "A tutorial for HMIPv6 modelling and simulation in IPV6 Suite". *Australian Telecommunications, Networks and Applications Conference*, Sydney, December 2004, pp. 437-440.

B.K. Lau, M. Viberg, **Y.H. Leung**, "Data-adaptive array interpolation for DOA estimation in correlated signal environments.” *IEEE International Conference on Acoustics, Speech and Signal Processing*, Philadelphia PA, March 2005, vol. 4, pp. 945-948.

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S.-Y. Low, **S. Nordholm**, "A blind approach to joint noise and acoustic echo cancellation." *IEEE International Conference on Acoustics, Speech and Signal Processing*, Philadelphia PA, March 2005, vol 3, pp. 69-72.

S.-Y. Low, **S. Nordholm**, "A robust multichannel speech enhancement method based on decorrelation.” *IEEE International Symposium on Circuits and Systems*, Kobe, Japan, May 2005, pp. 2875-2878.

M. Males, **A. Cantoni**, **J. Tuthill**, "Suppression of transient gain excursions in EDFAs". *IFIP Optical Networks and Technologies Conference*, Pisa, Italy, October 2004, pp. 319-316.

N. Moore, **Y. A. Sekercioglu**, **G.K. Egan**, "Virtual localization for Mesh Network Routing." *International Conference on Networks and Communication Systems*, April 2005, Thailand, pp. 126-132.

E. Östlin, **H. Suzuki**, **H.-J. Zepernick**, “Analysis of correlation between Ricean K-Factor and vegetation density surrounding a CDMA mobile terminal.” *IEEE International Symposium on Wireless Communication Systems*, Mauritius, September 2004, pp. 61-65.

E. Östlin, **H.-J. Zepernick**, **H. Suzuki**, "Small-scale fading prediction using an artificial neural network." *IEEE Vehicular Technology Conference*, Spring, Stockholm, Sweden, May 2005, pp. not available.

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B. Rohani, **H.-J. Zepernick**, B. Rohani, "Application of a perceptual speech quality metric for link adaptation in wireless systems." *IEEE International Symposium on Wireless Communication Systems*, Mauritius, September 2004, pp. 260-264.

C. Ryan, A. Gonsalves, "The effect of context and application type on mobile usability: an empirical study." *28th Australasian Computer Science Conference*, Newcastle, Australia, February 2005, pp. 115-124.

C. Ryan, **P. Rossi**, G. Fernandez, "Modeling with metrics the relationships between software attributes in context-aware mobile applications." *ACM SIGMETRICS, International Conference on Measurement & Modeling of Computer Systems*, Banff, Canada, June 2005, pp. not available.

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S. Spiteri, **G. Lebrun**, **M. Faulkner**, "Prediction for time varying SVD systems." Personal, Indoor and Mobile Radio Communications, Barcelona, Spain, September 2004, pp. not available.

R. Suryasaputra, **J. Murphy**, **R. Harris**, "Dousing hot spots in OSPF networks." *Australian Telecommunications Networks and Applications Conference*, Sydney, December 2004.

J. Trinkle, **A. Cantoni**, "Impedance analysis of power ground planes loaded with multiple capacitors." *EMC 2005 Conference*, Zurich, Switzerland, February 2005, pp. 257-262.

J. Trinkle, **A. Cantoni**, "Single summation expression for the rectangular power ground plane cavity." *EMC 2005 Conference*, Zurich, Switzerland, February 2005, pp. 247-250.

S. Venkatachalaiah, **R. J. Harris**, **R. Suryasaputra**, "Improvement of handoff in wireless networks using mobility prediction and multicasting techniques." *4th WSEAS International Conference on Electronics, Hardware, Wireless & Optical Communications*, Salzburg, Austria, February 2005, no pp. available.

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M. Williamson, **M. Faulkner**, "An improved adaptation scheme for an adaptive duplexer." *The 3rd Workshop on the Internet, Telecommunications and Signal Processing*, Adelaide, December 2004, on CDROM, no pp numbers.

B. Wong, **A. Cantoni**, **K. Fynn**, **J. Trinkle**, "Effect of modelling fringing and losses for a microstrip on the radiated emission characteristics." *EMC 2005 Conference*, Zurich, Switzerland, February 2005, pp. 557-562.

S. Woon, **Y.A. Sekercioglu**, **N. Mani**, "Application based handovers for effective mobile node distribution over a wireless enterprise network." *Australian Telecommunications, Networks and Applications Conference*, Sydney, December 2004, pp. 461-464.

E. Wu, **J. M. Lai**, **Y.A. Sekercioglu**, A simulation model of Mobile IPv6 protocol. *Australian Telecommunications, Networks and Applications Conference*, Sydney, December 2004, pp. 425-428.

E. Wu, **S. Woon**, **J. Lai**, **Y.A. Sekercioglu**, "IPv6Suite: A simulation tool for modeling protocols of the next generation internet." *Third International Conference on Information Technology: Research and Education*, Taiwan, June 2005, no pp. available.

E. Wu, **Y.A. Sekercioglu**, **G. Daley,** S. Narayanan, "An analytical study of direct and indirect signaling for Mobile IPv6 in mobile-to-mobile communications." *Tenth IEEE Symposium on Computers and Communications*, Cartagena, Spain, June 2005, pp. not available.

11.6 Conference Papers Accepted

F.O. Alayyan, **Y.H. Leung**, A.M. Zoubir, "A fast adaptive blind channel estimation for ZP-OFDM system." *IEEE Statistical Signal Processing Workshop*, Bordeaux, France, July 2005.

S. Citro, **J. McGovern**, **C. Ryan**, "An efficient consistency management algorithm for real-time mobile collaborations." *Fifth International Conference on Quality Software*, Melbourne Vic, September 2005.

G. Cresp, **H.-J. Zepernick**, **H.H. Dam**, "Combination Oppermann sequences for spread spectrum systems." *IEEE International Symposium on Information Theory*, Adelaide SA, September 2005.

G. Cresp, **H.-J. Zepernick**, **H.H. Dam**, "Periodic Oppermann Sequences for Spread Spectrum Systems." *Information Theory Workshop*, Rotorua, New Zealand, Aug-Sept 2005.

H.Q. Dam, **S. Nordholm**, **H. H. Dam**, **S. Y. Low**, "Multi-channel adaptive beamforming with source spectral and noise covariance matrix estimations." *International Workshop on Acoustic Echo and Noise Control*, Eindhoven, The Netherlands, September 2005.

H.Q. Dam, **S. Nordholm**, **H. H. Dam**, **S. Y. Low**, "Maximum likelihood estimation and Cramer-Rao lower bounds for the multi-channel spectral evaluation in hands-free communication." *Asia-Pacific Conference on Communications*, Perth WA, October 2005.

A.A. El-Sallam, **Y.H. Leung**, A.M. Zoubir, "On the selection of significant multi-path components for parsimonious DS-CDMA RAKE receiver: A covariance bootstrap based approach." *11th Asia-Pacific Conference on Communications,* Perth, Australia, October 2005.

A.A. El-Sallam, **Y.H. Leung**, A.M. Zoubir, "A frequency domain sphericity test based approach for parsimonious RAKE receiver in CDMA systems." *8th International Symposium on Signal Processing and its Applications*, Sydney, Australia, Aug-September 2005.

S. Eum, **J. Murphy**, **R. Harris**, "A fast accurate LP approach for Traffic Matrix estimation." *19th International Teletraffic Congress*, Beijing, China, August-September 2005.

A.A. Kist, “A flow blocking model for IP overflow traffic.” *Asia-Pacific Conference on Communications*, Perth WA, October 2005.

A.A. Kist, B. Lloyd-Smith, **R.J. Harris**, "A simple IP flow blocking model.” *19th International Teletraffic Congress*, Beijing, China, August-September 2005.

T.M. Kusuma, **H.-J. Zepernick**, **M. Caldera**, “On the development of a reduced-reference perceptual image quality metric.” *International Conference on Multimedia Communications Systems,* Montreal, Canada, August 2005.

T.M. Kusuma, **M. Caldera**, **H.-J. Zepernick**, “Utilizing perceptual image quality metrics for link adaptation based on region of interest.” *International Symposium on Wireless Communication Systems*, Siena, Italy, September 2005.

Y.H Leung, "An alternative derivation of the Durbin Method for MA spectrum estimation." *8th International Symposium on Signal Processing and its Applications*, Sydney, Australia, Aug-Sept 2005.

A. Lim, **H.H. Dam**, **S. Nordholm**, “Filter bank design for DFT-based transmultiplexers.” *Asia-Pacific Conference on Communications*, Perth WA, October 2005.

S.-Y. Low, **S. Nordholm**, **H.Q. Dam**, “A spatio-temporal-spectral processor for duplex hands-free communication systems.” *International Workshop on Acoustic Echo and Noise Control,* Eindhoven, The Netherlands, September 2005.

M. Males, **A. Cantoni**, “Experimental comparison of two pump control schemes for suppressing transient gain excursions in EDFAs.” *Asia-Pacific Optical Communications Conference,* Shanghai, China, November 2005.

E. Östlin, **H. Suzuki**, **H.-J. Zepernick**, "Evaluation of a new effective antenna height definition in P.1546-1." *11th Asia-Pacific Conference on Communications*, Perth WA, October 2005.

B. Rohani, **H.-J. Zepernick**, B. Rohani, “An efficient method for perceptual evaluation of speech quality in UMTS.” *International Conference on Multimedia Communications Systems*, Montreal, Canada, August 2005.

B. Rohani, B. Rohani, H. Hosseini, **H.-J. Zepernick**, “Combined AMR mode adaptation and fast power control for GSM Phase 2+.” *Asia-Pacific Conference on Communications*, Perth WA, October 2005.

C. Ryan, **P. Rossi**, "Software, performance and resource utilisation metrics for context-aware mobile applications.” *11th IEEE International Software Metrics*, Como, Italy, September 2005.

V. Venkat Kumar, **F.-C. Zheng**, "On the performance of constellation rotated NO-STBC over correlated fading channels.” *IEEE Vehicular Technology Conference*, Dallas, Texas, September 2005.

S. Venkatachaliah, **R. Harris**, "Improving handoff in wireless networks using mobility prediction and evolutionary algorithms.” *International Conference on E-Business and Telecommunication Networks, Second International Conference on E-business and Telecommunications Networks*, Reading UK, October 2005.

M. Wahab, A.M. Zoubir, “A subspace-based blind channel estimation for zero-padded MC-CDMA.” *11th Asia-Pacific Conference on Communications,* Perth, Australia, October 2005.

Y. Yatawara, **M. Caldera**, **T.M. Kusuma**, **H.-J. Zepernick**, “Unequal error protection for ROI coded images over fading channels.” *International Conference on Multimedia Communications Systems*, Montreal, Canada, August 2005.

H.-J. Zepernick, **W. Griffiths**, **M. Caldera**, “APP Decoding of binary block codes on Gilbert-Elliott channels.” *International Symposium on Wireless Communication Systems*, Siena, Italy, September 2005.

11.7 Internet Drafts

J. Kempf, M. Khalil, **B. Pentland**, "IPv6 fast router advertisement FastRA.” July 2004.

B. Pentland, **G. Daley**, J. H. Choi, “Router advertisement link identification for Mobile IPv6 movement detection.” July 2004.

G. Daley, "Nonce response matching for router reachability in IPv6.” November 2004.

G. Daley, **B. Pentland**, “Deterministic fast router advertisement configuration.” July 2004.

G. Daley, **G. Kurup**, "Trust models and security in multicast group management.” July 2004.

G. Daley, **N. Moore**, "Tentative source link-layer address options for IPv6 neighbour discovery.” November 2004.

G. Daley, “Securing proxy neighbour discovery problem statement.” July 2004.

N. Moore, J. Choi, **B. Pentland**, "Edge handovers for Mobile IPv6.” July 2004.

N. Moore, J. Choi, **B. Pentland**, "Tunnel buffering for Mobile IPv6.” July 2004.

11.8 Standards Proposals

Scott Leyonjhelm, Mike Faulkner, Vasantha Crabb, Melvyn Pereira, Tan Ying, Jason Gao, Aaron Reid, "Partial proposal (physical layer) for extending the 802.11-1000 standard.” 13 August 2004.

Scott Leyonjhelm, Mike Faulkner, Vasantha Crabb, Melvyn Pereira, Tan Ying, Jason Gao, Aaron Reid, "A ‘high throughput’ partial proposal presentation." 13 September 2004.

11.9 Maintained Patents

These patents were maintained during the year:

SIGNAL PEAK REDUCTION CIRCUIT FOR NON-CONSTANT ENVELOPE MODULATION SIGNALS

International Patent Application No. PCT/AU01/00741
United States Patent Application No. 10/311,872
Chinese Patent Application No. 01811456.3

GATEWAY SYSTEM
- International Patent Application No. PCT/AU00/01413
- Japanese Patent Application No. 2001-538344
- United States Patent Application No. 10/130,430

METHOD AND APPARATUS FOR MANAGING THE STATISTICAL MULTIPLEXING OF DATA IN DIGITAL COMMUNICATION NETWORKS
- International Patent Application No. PCT/AU94/00150
- United States Patent No. 5,689,499

CHANNEL ESTIMATION FOR OFDM SYSTEMS
- International Patent Application No. PCT/AU2004/001704

EFFICIENT FRAME FORMAT FOR WIRELESS SYSTEMS
- International Patent Application (now lapsed)

METHOD AND APPARATUS FOR TRANSFER OF REAL TIME SIGNALS OVER PACKET NETWORKS
- International Patent Application No. PCT/AU99/00396
- Australian Patent No. 763935
- European Patent Application No. 99923316.6
- Japanese Patent Application No. 2000-550246
- United States Patent No. 6,876,670

DUAL SENSING OPTO-ELECTRONIC RECEIVER
- Australian Patent No. 752142

PRECISE DIGITAL FREQUENCY DETECTION
- International Patent Application No. PCT/AU97/00407
- Australian Patent No. 731217
- German Patent Application No. 19781842.0
- Japanese Patent Application No. 10-503667
- United States Patent No. 6,448,757

STEERED FREQUENCY PHASE LOCKED LOOP
- International Patent Application No. PCT/AU95/0793
- Australian Patent No. 710299
- Chinese Patent Application No. 95197480.7
- European Patent No. 0795234
- United States Patent No. 6,031,428

SWITCHING PROTOCOL PROVIDING CONTROLLED ACCESS TO AVAILABLE ASYNCHRONOUS NETWORK SERVICE
- International Patent Application No. PCT/AU95/00451
- United States Patent No. 6,411,627

12 Communication Strategy

This year, ATcrc continued its involvement in ATNAC and expanded its conference organisational involvement to *APCC 2005*, *Tencon'05* and *VTC-Spring 2006*. ATcrc also exhibited at CeBIT Australia 2005 as part of the research and development dedicated *future parc* section.

12.1 Conference Organisation Involvement

ATcrc representatives have provided valuable and ongoing assistance to the organising committees of four Australian-based conferences.

Australian Telecommunications Networks and Applications Conference

ATNAC was held in December 2004 at the Bondi Swiss Grand in Sydney. The Smart Internet Technology CRC was primarily responsible for its organisation, with assistance provided from ATcrc. With the arrival of a similarly themed conference for the IEEE Region 10, ATNAC 2005 is a technical co-sponsor of Tencon'05. ATcrc is committed to ensuring ATNAC's continued existence with the development of a Steering Committee.

Asia-Pacific Conference on Communications
Perth, Western Australia
3 – 5 October 2005

Professor Sven Nordholm of WATRI is the Chair of the Technical Program Committee for APCC 2005. Assistance has been provided to Professor Nordholm with the promotional aspects of APCC and the development and design of the Conference Abstract Book.

IEEE Tencon'05
Melbourne, Victoria
21 – 24 November 2005

As primary organisers of ATNAC 2005, Dr Leith Campbell and Ms Sarah Craze were invited to join the Organising Committee of Tencon'05. Tencon is the IEEE's annual Region 10 Conference. Ms Craze manages the Tencon website and provides ongoing liaison assistance with the development of the registration process and overall publicity. She is also assisting in the development of the Tencon Exhibition.

63rd Vehicular Technology Conference, Spring 2006
Melbourne, Victoria
7 – 10 May 2006

For the first time in over fifty years, the prestigious bi-annual VTC will be held in the southern hemisphere. Chaired by Victoria University's Professor Fu-Chun Zheng, VTC will include representatives of ATcrc on the organising committee with Ms Sarah Craze as Publicity Chair.

12.2 CeBIT Australia 2005

Darling Harbour Exhibition Centre, Sydney NSW
24 – 26 May 2005

The opportunity to exhibit at CeBIT Australia in 2005 provided ATcrc with a showcase of some of our current and ongoing software and hardware tools. ATcrc exhibited as part of *future parc*, the dedicated R&D section. Displays included the OptiFlow Internet Routing Optimisation Tool (Networking Program), Overflow Routing Tool (Networking Program) and MobJeX Java Objects (Applications Program). ATcrc was also pleased to host a prototype of the Microphone Array Speech Enhancement system developed by one of our partners, the WA Telecommunications Research Institute.

The demonstrations were well received by visitors to the stand and academic and commercial leads were developed.

12.3 Introduction to IPv6 Protocols

The Applications Program's half-day workshop on IPv6 has had a very positive response, particularly in the difficult climate of the ICT training and development sector. The workshop has been presented to Telstra and as part of the Ballarat Innovation Festival. Our thanks to the presenters from Monash University, Gopi Kurup, Brett Pentland and Ahmet Sekercioglu for their continued commitment.

12.4 ATcrc Sponsorship Activities

ATcrc sponsored the 8th International Symposium on DSP for Communication Systems, December 2004.

ATcrc was a founding sponsor of the Australian i-Mode Forum, managed by Digital Investor Pty Ltd.

12.5 Annual Review

For the second year, ATcrc distributed an Annual Review. The Annual Report for 2003/2004 was published on CDROM and distributed within the Review. This year, ATcrc will again produce a Review. It is designed to showcase the highlights of ATcrc's research and work over the last year.

12.6 *Wave* Newsletter

Two issues of *Wave* were produced during the year. These featured the Applications Program (January 2005) and the Education Program (April 2005). ATcrc has expanded the content of *Wave* to include news on commercialisation activities, licensing and student projects. The newsletter is distributed to over 500 ATcrc contacts.

12.7 ATeam Newsletter

Internal communication between staff, students, Board members and industry partners has been continued with the production of the fortnightly ATeam Newsletter. Each issue provides pertinent articles from the preceding two weeks, CRC events, news and information for staff. The newsletter is distributed by email and also accessible in ATcrc's document library, Infotrove.

13 Grants and Awards

Prof Richard Harris won the RMIT Research Publications Award 2004/Set Portfolio Research Teaching Award and was a member of the winning Vice Chancellor's Research Award 2004.

Behrooz Rohani of WATRI won the IEEE Excellent Paper Award at International Symposium on Wireless Communication Systems, Mauritius, September 2004 for his paper, "*Application of a perceptual speech quality metric for link adaptation in wireless systems*".

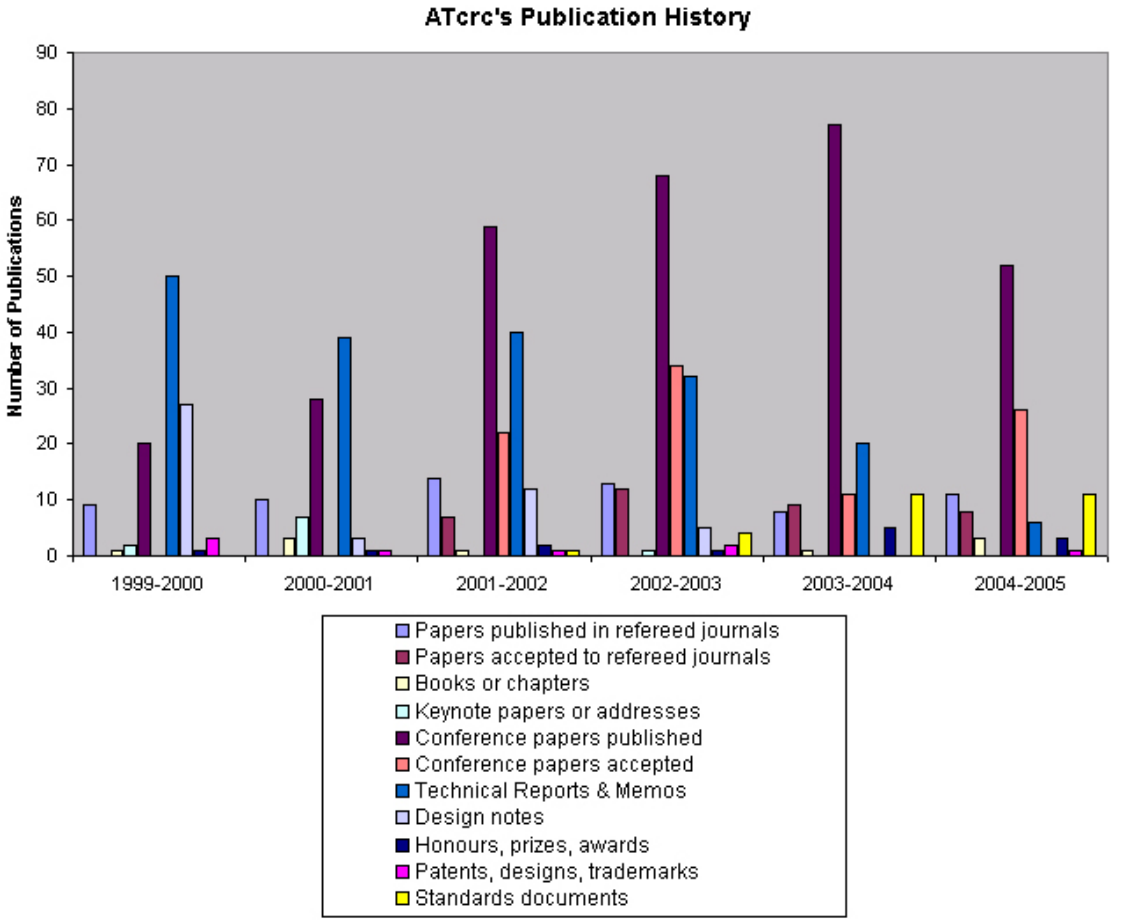
Siow Yong Low of WATRI won the Best Oral Presentation Award at the Postgraduate Electrical Engineering and Computing Symposium, September 2004 for his paper, "*The blind generalized sidelobe canceller*".

Greg Day of WATRI won the Best Paper Award, Postgraduate Electrical Engineering and Computing Symposium, September 2004 for his paper, "*Subband adaptive equalisation: MSE reductions through optimised alignment delays*".

14 Performance Measures

14.1 Non-Financial

Quality and Relevance of the Research Program



	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005
Papers published in refereed journals	9	10	14	13	8	11
Papers accepted to refereed journals	†	†	7	12	9	8
Books or chapters	1	3	1	0	1	3
Keynote papers or addresses	2	7	0	1	0	0
Conference papers published	20	28	59	68	77	52
Conference papers accepted	†	†	22	34	11	26
Technical Reports & Memos	50	39	40	32	20	6
Design notes	27	3	12	5	0	0
Honours, prizes, awards	1	1	2	1	5	3
Patents, designs, trademarks	3	1	1	2	0	1
Standards documents	0	0	1	4	11	11

† Data unavailable

14.2 Communication

Internal

ATcrc has a weekly management communication meeting held at sites in Perth and Melbourne via teleconference. Individual project meetings are held weekly at the research sites and program meetings occur as required. Research documentation is stored in a single, online environment, *Infotrove*, accessible to all researchers via the Web.

A fortnightly newsletter, "ATeam News", is distributed via email to approximately 100 participants in ATcrc, including research staff, Board members and industry representatives.

External

ATcrc publishes a hard-copy newsletter, *Wave*, of which two issues were published in 2004/2005. This is distributed globally to approximately 550 recipients. Each issue reports progress in a particular ATcrc program and contains information about research partners and personnel. *Wave* is available on ATcrc's website.

A major communications vehicle is ATcrc's website (http://www.telecommunications.crc.org.au).

Reporting

Quarterly progress reports are compiled for each project and Program. The program leaders produce a Program overview. The relevant Research Executive approves all reports. Reports are available two weeks after the end of each quarter and are submitted to the next meeting of the Executive Research Committee.

A major review of one Program is held each quarter, generally the day before the Executive Research Committee meeting. The review report is written immediately after the review and is available for consideration at the Committee meeting.

During 2004/2005, the following reviews were conducted:

- Networking Research Program, July 2004;
- Applications Research Program, October 2004;
- Wireless Research Program, January 2005.

An Education Program Review was not held. Instead, a Showcase of the Education Program's activities was held in May 2005.

A review of the Communications Electronics Research Program will be conducted in October 2005. The remaining Networking Program projects will be reviewed with the Applications Program in October 2005.

15 New from existing CRCs

Not applicable.

16 Financial Information

The financial statements have been audited and the auditor's statement and a summary of the audited financial statements are included in the following pages. The financial information referred to in the Auditor's Report are Tables 1 to 3, which are available from ATcrc.

The statement entitled 'Statement of Financial Performance' shows the current position including the accrual of invoices received after 30 June 2005 that relate to claims for the financial year 2004/2005. This statement was not part of the Auditor's Report.

The Agreement referred to in the financial statements is Schedule 4 in the ATcrc Commonwealth Agreement, updated with effect from 1 July 2003. The contract variation to the ATcrc Commonwealth Agreement giving effect to the new Schedule 4 was formally signed off by the CRC's core partners and the Commonwealth in August 2004.

The following changes have occurred in ATcrc's core partnership since the formation of the Centre:

- Agilent Technologies Australia Pty Ltd became the core partner in place of Hewlett Packard Australia Pty Ltd in 1999/2000, as provided in clause 29.3 of the Centre Agreement;
- Agilent Technologies Australia Pty Ltd withdrew as a core partner in 2001/2002;
- Indian Pacific Communications Pty Ltd: its assets and undertakings were acquired by Open Telecommunications Ltd in 1999/2000; Indian Pacific Communications began trading again in 2002 but has not been contactable and has been written out of the updated Commonwealth Agreement.
- The Strategic Industry Research Foundation Ltd assigned its continuing interest in ATcrc to the Victorian Department of State and Regional Development at the end of 1999/2000. The Victorian Government has subsequently supported ATcrc at the level originally planned.
- Radio Frequency Systems Australia ceased its participation in 1999/2000.

Supporting partners:

- QPSX Communications Pty Ltd became a supporting partner in 2000/2001;
- Tait Electronics Ltd became a supporting partner in 2002/2003;
- The Victorian Government formally became a supporting partner in 2002/2003 through the re-establishment of its support agreement.

The CRC-BTN Trust, which holds equity in a company previously spun off from CRC-BTN, realised some of its holding and provided cash support to ATcrc in 2001/2002, 2002/2003, 2003/2004 and 2004/2005 for research and commercialisation.

Statement of Financial Performance (accrual position)

Contributions and Expenditure	1999/2000 ACTUAL $'000	2000/2001 ACTUAL $'000	2001/2002 ACTUAL $'000	2002/2003 ACTUAL $'000	2003/2004 ACTUAL $'000	2004/2005 $'000	2004/2005 AGREEMENT $'000	CUMULATIVE ACTUAL $'000	CUMULATIVE AGREEMENT $'000
Core Partners									
Curtin University of Technology	200	200	300	200	175	142	186	1,217	1,355
RMIT University	-	100	200	50	150	100	100	600	600
University of Western Australia	100	100	100	100	100	100	100	600	600
Monash University	100	100	100	100	100	100	100	600	600
Victoria University of Technology	100	100	100	100	100	100	100	600	600
Ericsson Australia Pty Ltd	150	150	150	300	100	100	100	950	950
Vodafone Network Pty Ltd	-	200	110	90	100	100	100	600	600
* Strategic Industry Research Foundation Ltd	-	150	-	-	-		-	150	150
* Indian Pacific Communications	10	-	-	-	-		-	10	10
* Agilent Technologies	-	20	10	-	-		-	30	30
Total Cash From Core Partners	**660**	**1,120**	**1,070**	**940**	**825**	**742**	**786**	**5,357**	**5,495**
Supporting Partners									
CRC-BTN	605	780	-	-	-	62	-	1,447	1,385
WA State Government	-	353	113	(17)	104	31	22	583	589
* Atmosphere Networks Pty Ltd	217	-	-	-	-		-	217	218
* Lucent Technologies Australia Pty Ltd	10	10	-	-	-		-	20	20
Victorian Government	-	-	-	50	50	50	50	150	150
Tait Electronics Ltd	-	-	-	20	20		20	40	60
QPSX Communications Pty Ltd	-	20	20	-	20		20	60	80
Total Cash from Supporting Partners	**832**	**1,163**	**133**	**53**	**194**	**143**	**112**	**2,517**	**2,502**
Total Cash from Partners	**1,492**	**2,283**	**1,203**	**993**	**1,018**	**885**	**898**	**7,874**	**7,997**
Other Cash									
CRC-BTN Trust Share Distribution UWA	-	16	130	304	-		-	450	450
CRC-BTN Trust Share Distribution Curtin	-	27	119	183	121		-	450	448
CRC-BTN Trust Share Distribution Commercialisation	-	95	-	-	-		-	95	95
Commercial Revenue	140	26	97	101	243	132	100	739	651
Interest Received	5	132	234	66	(75)	57	14	419	381
Total Other Cash	**145**	**296**	**580**	**654**	**289**	**189**	**114**	**2,153**	**2,025**
CRC Grant	**1,900**	**2,600**	**2,400**	**2,300**	**2,300**	**2,200**	**2,200**	**13,700**	**13,700**
Total CRC Cash	**3,537**	**5,179**	**4,183**	**3,947**	**3,607**	**3,274**	**3,212**	**23,727**	**23,722**
Cash carried over from previous year	**-**	**148**	**1,995**	**1,647**	**565**	**435**	**281**		
Less Unspent Balance	**148**	**1,995**	**1,647**	**565**	**435**	**650**	**13**		
Total Cash Expenditure	**3,389**	**3,332**	**4,531**	**5,029**	**3,737**	**3,059**	**3,480**		
Allocations of Cash Expenditure									
Salaries	**2,254**	**2,315**	**3,021**	**3,354**	**2,312**	**1,830**	**2,046**	**15,086**	**15,307**
Capital	**144**	**112**	**122**	**130**	**60**	**134**	**90**	**702**	**778**
Other	**991**	**905**	**1,388**	**1,545**	**1,365**	**1,095**	**1,344**	**7,289**	**7,625**

* Indicates not a participant in years five to seven.

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Independent audit report to the Australian Telecommunications Cooperative Research Centre (ATcrc)

Scope

We have audited the attached financial information, which comprises the statement of in-kind contribution from partners, the statement of cash contributions and summary of resources applied to activities of the centre, for the Australian Telecommunications Cooperative Research Centre (ATcrc) for the year ended 30 June 2005. It has been prepared for distribution to the Cooperative Research Centres Program, Department of Education, Science and Training (the Commonwealth) for the purpose of fulfilling the requirements of the Commonwealth Agreement dated 20 October 1999, as varied by the Commonwealth Agreement dated 26 August 2004.

The board of management of ATcrc is responsible for the preparation and presentation of the financial information in accordance with the Commonwealth Agreement. We conducted an independent audit of the financial information in order to express an opinion on it to the board of management of ATcrc. We disclaim any assumption of responsibility for any reliance on this audit report or on the financial information to which it relates to any person other than the board of management of ATcrc and the Commonwealth, or for any purpose other than that for which they were prepared.

Our audit was conducted in accordance with Australian Auditing Standards. Our procedures included the examination, on a test basis, of evidence supporting the amounts disclosed in the financial information. These procedures have been performed to assess whether in all material respects the financial information is presented fairly in accordance with the Commonwealth Agreement (specifically those provisions referred to in section 17 of the CRC Program Guidelines for Annual Reports June 2005).

Qualifications

Clause 4 (Participant Contributions)

As required by Clause 4 of the Commonwealth Agreement, each participant's component of the Researcher's contributions for the year ended 30 June 2005 has been provided at least to the value committed in the Budget as specified in the Commonwealth Agreement, with the following exceptions:

Organisation	Budgeted Contribution			Actual Contribution		
	In-Kind $'000	Cash $'000	Total $'000	In-Kind $'000	Cash $'000	Total $'000
University of Western Australia	1,728	100	1,828	1,556	100	1656
QPSX	0	20	20	0	0	0
Ericsson Australia Pty Ltd	434	100	534	0	100	100
TAIT Electronics	113	20	133	0	0	0
CSIRO	638	0	638	1	0	1
Monash University	1,402	100	1,502	1,032	100	1132
Vodafone	9	100	109	0	100	100

Clause 5 (Application of Grant and Contributions)

Clause 5 of the Commonwealth Agreement (as varied) allows the Researcher's reallocations of the budgetary resources between Heads of Expenditure, as specified in the Commonwealth Agreement (as varied), to differ from the Budget allocation, provided the difference is not more than 20% or $100,000, whichever is the greater amount. The ATcrc's allocations differ by more than $100,000 in respect of both Salaries and Other expenditure. The actual Salary expenditure was $3,080,000 compared to budgeted Salary expenditure of $3,573,000, resulting in a shortfall of $493,000. The actual Other expenditure was $4,587,000 compared to a budgeted Other expenditure of $5,573,000, resulting in a shortfall of $986,000.

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Qualified Audit opinion

In our opinion, except for the matters referred to in the qualifications above, the attached financial information for the ATcrc presents fairly, in accordance with Australian Accounting Standards and the provisions of the Commonwealth Agreement dated 20 October 1999 as varied by the Commonwealth Agreement dated 26 August 2004, the sources of funding and the application of that funding for the year ended 30 June 2005.

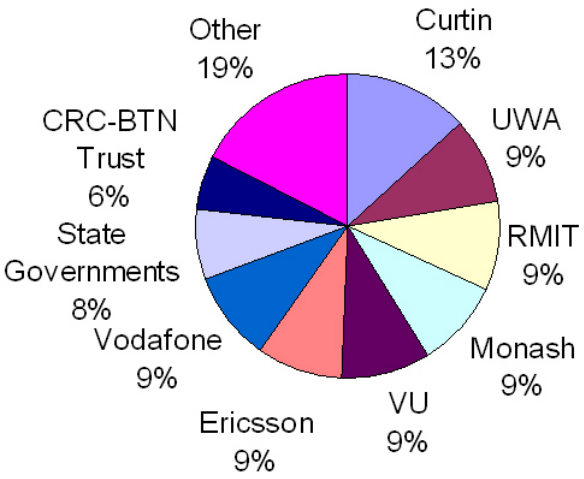
PricewaterhouseCoopers

PricewaterhouseCoopers

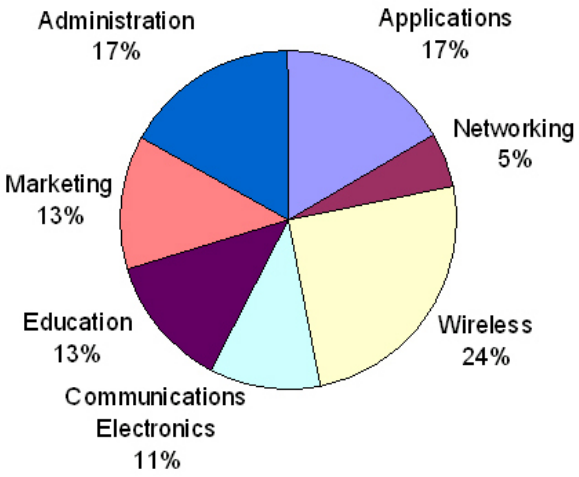
S T Maher
Partner

Perth
27 September 2005

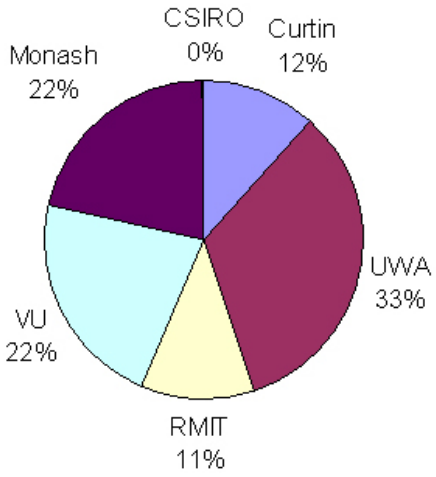
Revenue Sources 2004/2005
(other than CRC Grant)



Cash Expenditure 2004/2005



In-kind Support from Partners 2004/2005



In Kind Contributions

* indicates not a participant in years five to seven.

			1999/2000	2000/2001	2001/2002	2002/2003	2003/2004	2004/2005		CUMULATIVE	
			ACTUAL	ACTUAL	ACTUAL	ACTUAL	ACTUAL	ACTUAL	AGREEMENT	ACTUAL	AGREEMENT
Core Partners			$'000	$'000	$'000	$'000	$'000	$'000	$'000	$'000	$'000
Curtin University of Technology		Salaries	639	559	332	317	246	196	215	2,289	2,273
		Capital	39	39	39	39	39	38	39	233	234
		Other	2,385	1,743	1,698	377	236	338	80	6,777	6,362
		Total	**3,063**	**2,341**	**2,069**	**733**	**521**	**572**	**334**	**9,299**	**8,869**
RMIT University		Salaries	206	136	94	108	138	103	139	785	819
		Capital	-	-	-	-	-	-	-	-	-
		Other	476	450	585	640	596	441	397	3,188	3,261
		Total	**682**	**586**	**679**	**748**	**734**	**544**	**536**	**3,973**	**4,080**
University of Western Australia		Salaries	61	326	266	196	560	259	226	1,668	1,341
		Capital	-	-	-	-	-	60	-	60	-
		Other	407	1,034	1,227	2,500	2,461	1,237	1,502	8,866	8,537
		Total	**468**	**1,360**	**1,493**	**2,696**	**3,021**	**1,556**	**1,728**	**10,594**	**9,878**
CSIRO		Salaries	84	43	76	86	6	-	130	295	545
		Capital	-	-	-	-	-	-	-	-	-
		Other	342	295	337	349	248	1	508	1,572	2,335
		Total	**426**	**338**	**413**	**435**	**254**	**1**	**638**	**1,867**	**2,880**
Ericsson Australia Pty Ltd		Salaries	296	135	77	145	-	-	193	653	1,040
		Capital	-	-	-	-	-	-	-	-	-
		Other	397	180	103	193	-	-	241	873	1,353
		Total	**693**	**315**	**180**	**338**	**-**	**-**	**434**	**1,526**	**2,393**
Victoria University of Technology		Salaries	173	191	210	247	369	343	195	1,533	1,207
		Capital	-	-	-	-	-	-	-	-	-
		Other	420	434	508	576	777	722	503	3,437	3,005
		Total	**593**	**625**	**718**	**823**	**1,146**	**1,065**	**698**	**4,970**	**4,212**
Monash University		Salaries	373	350	346	354	310	210	314	1,943	2,044
		Capital	117	111	97	97	97	97	97	616	616
		Other	589	1,115	1,039	837	715	725	991	5,020	5,592
		Total	**1,079**	**1,576**	**1,482**	**1,288**	**1,122**	**1,032**	**1,402**	**7,579**	**8,252**
*	Indian Pacific Communications	Salaries	103	-	-	-	-	-	-	103	103
		Capital	-	-	-	-	-	-	-	-	-
		Other	83	-	-	-	-	-	-	83	83
		Total	**186**	**-**	**-**	**-**	**-**	**-**	**-**	**186**	**186**
	Vodafone Network Pty Ltd	Salaries	26	39	5	4	5	-	4	79	81
		Capital	-	-	-	-	-	-	-	-	-
		Other	32	61	-	-	-	-	5	93	103
		Total	**58**	**100**	**5**	**4**	**5**	**-**	**9**	**172**	**184**
*	Agilent Technologies	Salaries	-	5	35	-	-	-	-	40	40
		Capital	-	-	51	-	-	-	-	51	51
		Other	86	0	14	-	-	-	-	100	100
		Total	**86**	**5**	**100**	**-**	**-**	**-**	**-**	**191**	**191**
Total core in-kind contributions		**Salaries**	**1,961**	**1,784**	**1,441**	**1,457**	**1,634**	**1,111**	**1,416**	**9,388**	**9,493**
		Capital	**156**	**150**	**187**	**136**	**136**	**195**	**136**	**960**	**901**
		Other	**5,217**	**5,312**	**5,511**	**5,472**	**5,033**	**3,464**	**4,227**	**30,009**	**30,731**
		TOTAL	**7,334**	**7,246**	**7,139**	**7,065**	**6,803**	**4,770**	**5,779**	**40,357**	**41,125**
Supporting Partners											
Sun Microsystems		Salaries	-	-	-	-	-	-	-	-	-
		Capital	52	26	123	49	-	-	-	250	300
		Other	131	75	60	167	177	-	-	610	599
		Total	**183**	**101**	**183**	**216**	**177**	**-**	**-**	**860**	**899**
Semiconductor Technologies Australia		Salaries	-	-	8	-	-	-	-	8	8
		Capital	-	-	5	-	-	-	-	5	5
		Other	-	-	-	-	-	-	-	-	-
		Total	**-**	**-**	**13**	**-**	**-**	**-**	**-**	**13**	**13**
TAIT Electronics Ltd		Salaries	-	-	-	217	-	-	111	217	549
		Capital	-	-	-	-	-	-	-	-	-
		Other	-	-	-	3	-	-	2	3	8
		Total	**-**	**-**	**-**	**220**	**-**	**-**	**113**	**220**	**557**
Total Supporting In-Kind Contributions		**Salaries**	**-**	**-**	**8**	**217**	**-**	**-**	**111**	**225**	**557**
		Capital	**52**	**26**	**128**	**49**	**-**	**-**	**-**	**255**	**305**
		Other	**131**	**75**	**60**	**170**	**177**	**-**	**2**	**613**	**607**
		Total	**183**	**101**	**196**	**436**	**177**	**-**	**113**	**1,093**	**1,469**
Total In-Kind Contributions		**Salaries**	**1,961**	**1,784**	**1,449**	**1,674**	**1,634**	**1,111**	**1,527**	**9,613**	**10,050**
		Capital	**208**	**176**	**315**	**185**	**136**	**195**	**136**	**1,215**	**1,206**
		Other	**5,348**	**5,387**	**5,571**	**5,642**	**5,210**	**3,464**	**4,229**	**30,622**	**31,338**
Grand Total (In-Kind)			**7,517**	**7,347**	**7,335**	**7,501**	**6,980**	**4,770**	**5,892**	**41,450**	**42,594**
Grand Total (Cash Expenditure)			**3,389**	**3,332**	**4,531**	**5,029**	**3,737**	**3,059**	**3,480**	**23,077**	**23,710**
Grand Total (In-Kind Expenditure)			**7,517**	**7,347**	**7,335**	**7,501**	**6,980**	**4,770**	**5,892**	**41,450**	**42,594**
Total Resources Applied to Centre Activities			**10,906**	**10,679**	**11,866**	**12,530**	**10,717**	**7,829**	**9,372**	**64,527**	**66,304**

17 Acronyms

ATcrc	Australian Telecommunications Cooperative Research Centre
ATNAC	Australian Telecommunications Networks and Applications Conference
CASE	Computer Aided Software Engineering
CDMA	Code Division Multiple Access
CRC-BTN	Cooperative Research Centre for Broadband Telecommunications and Networking (ATcrc's predecessor)
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DFF	D-Type Flip-Flop
DNA	Detecting Network Attachment
DWDM	Dense Wavelength Division Multiplexed
EDFA	Erbium Doped Fibre Amplifiers
FPGA	Field-Programmable Gate Array
HMIPv6	Hierarchical Mobile Internet Protocol Version 6
ICT	Information & Communication Technology
IEEE	Institute for Electrical and Electronic Engineers
IETF	Internet Engineering Task Force
IP	Internet Protocol
IPRS	International Postgraduate Research Scholarship
IPv6	Internet Protocol Version 6 (IPv4 is Currently In Use)
ITU	International Telecommunications Union
LAN	Local Area Network
LP	Linear Programming
Mbps	Megabits per second
MEng	Masters by Research
MPLS	Multi Protocol Label Switching
MIMO	Multiple Input Multiple Output
MobJeX	Mobile Java Objects
NGI	Next-Generation Internet
OFDM	Orthogonal Frequency Division Multiplexing
PCI	Peripheral Component Interface
PDA	Personal Digital Assistant
PhD	Doctor of Philosophy
QoS	Quality of Service
RFC	Request for Comment (an IETF standards document)
SITCRC	Smart Internet Technology CRC
SME	Small or Medium Enterprise
SOCT	Serialization of Concurrent Transactions (an algorithm)
TRL	Telstra Research Laboratories
VoIP	Voice over Internet Protocol
VCO	Voltage Controlled Oscillator
WATRI	Western Australian Telecommunications Research Institute
W-CDMA	Wideband Code Division Multiple Access